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Ammonium Perchlorate Transportation Hazards Testing

April 1989

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FOREWORD

This special report describes the tests on AP transportation containers conducted at the Astronautics Laboratory (AFSC), Edwards Air Force Base CA and at the Naval Weapons Center, China Lake CA. The project was jointly funded by the Department of Defense and NASA. AL Project Manager was Capt Anthony Taliancich.

This report has been reviewed and is approved for release and distribution in accordance with the distribution statement on the cover and on the DD Form 1473.

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The incident at Pacific Engineering Production Company of Nevada (PEPCON) on 4 May 1988 raised concern over the transportation and storage safety of 208 liter (55 gallon) DOT Specification 1/H steel drums containing 227 kilograms (500 pounds) of ammonium perchlorate and 2045 to 2270 kilograms (4500 to 5 000 pounds) net weight ammonium perchlorate aluminum bins meeting requirements of DOT Specification 56. As a result these containers have been subjected to a series of transportation certification tests. Test procedures were obtained from the 1986 issue of the United Nations' publication, "Recommendations on the Transport of Dangerous Goods: Tests and Criteria," (ST/SG/AC.10/11), Test Series 6, Sections 41 through 44. The results of the tests for both drums and bins with nominal 200-micron particle size propellant grade ammonium perchlorate confirm the suitability of the US DOT classification as an oxidizer with ID number UN1442.

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PREFACE

The ammonium perchlorate (AP) hazards assessment program was initiated at the Astronautics Laboratory (AL). A request for the program came from Mr Daniel S. Rak, the Air Force Deputy Assistant Secretary for Acquisition Management and Policy in his capacity as Chairman of the Ammonium Perchlorate Management Steering Group for the Department of Defense (DoD), National Aeronautics and Space Administration (NASA) and industry. At the same time, the Navy was immediately authorized to initiate work in support of this effort by Mr Peter Gratton, also a member of the Management Steering Group. Dr Richard R. Weiss, Chief Scientist of the AL, organized and conducted a workshop at the AL which was attended by 21 experts representing government, industry and consultants. The workshop developed a program plan that addressed the ammonium perchlorate processing, storage and transportation issues. Dr Frank Roberto of the AL was assigned as the program manager. A technical consortium was formed to address the technical issues and to assist Dr Roberto in the conduct of the program plan. We would like to acknowledge the appreciated support received from the people of the Naval Weapons Center (NWC), China Lake and the Experimental Area 1-32, Component Testing Section, AL/TOAB for conduct of the DOT transportation testing.

We also acknowledge and commend the contributions of Aerojet Solid Propulsion Company, Atlantic Research Corporation, Hercules Corporation - Bacchus Division, Morton Thiokol Corporation - Wasatch Division, and United Technologies - Chemical Systems Division. We similarly acknowledge the contributions and cooperation of the two ammonium perchlorate production companies, Kerr-McGee Company and Pacific Engineering Production Company of Nevada (PEPCON). Without the cooperation and supplies furnished by these members of the industry, especially Kerr-McGee, this project would not have been as responsive.

INTRODUCTION

Following the ammonium perchlorate (AP) fire and explosions at Pacific Engineering Production Company of Nevada (PEPCON) on 4 May 1988 a group of experts was convened by Mr Daniel S. Rak, Chairman of the Ammonium Perchlorate Management Steering Group, to perform an assessment of AP hazards. A primary objective was to determine the acceptability of containers commonly used by the industry for shipping and storage of AP. Nominal 200-micron particle size propellant grade AP in 114 liter (30 gallon) DOT specification 37A-350 steel drums with bolted ring closures containing approximately 114 kilograms (250 pounds) of material had successfully undergone shipping container safety testing in 1982 (Ref. 1). However, the same material in 208 liter (55 gallon) DOT specification 17H steel drums containing approximately 227 kilograms (500 pounds) of AP and aluminum bins conforming to requirements of DOT Specification 56, containing from 2045 to 2270 kilograms (4500 to 5000 pounds) of AP, both of which were involved in the PEPCON incident, had not been subjected to the same testing. The larger containers had been approved by analogy with AP behavior in the 114 liter (30 gallon) steel drums.

This report covers results obtained from shipping container testing of the 208 liter (55 gallon) steel drums and DOT Specification 56 aluminum bins with nominal 200-micron particle size propellant grade AP. Test procedures were acquired from the United Nations' 1986 publication, "Recommendations on the Transport of Dangerous Goods: Tests and Criteria," (ST/SG/AC.10/11), Sections 41 through 44 (Ref. 2). Guidance and procedures were also received from Dr Jerry Ward from the Department of Defense Explosives Safety Board (DDESB) (Ref. 3) and the Department of the Air Force Technical Order, TO 11A-1-47, "Department of Defense Explosives Hazard Classification Procedures" (Ref. 4).

The Astronautics Laboratory (AL), Edwards Air Force Base CA and the Naval Weapons Center (NWC), China Lake CA performed Series 6 testing (Ref. 2) of AP transport containers described above between 8 November 1988 and 9 January 1989. Type 6 (a) single package tests of the drums and bins were conducted at the AL, as well as the type 6 (c) external fire (bonfire) test of the steel drums. The type 6 (c) external fire (bonfire) fire test of the aluminum bins was conducted at the NWC.

EXPERIMENTAL PROCEDURES AND TEST SETUP

TEST ARTICLES

There were two test articles evaluated under this program. The first test article was a 208 liter (55 gallon) DOT specification 17H steel drum with bolted ring closure containing approximately 227 kilograms (500 pounds) of nominal 200-micron particle size propellant grade AP. The AP was packaged in a polyethylene bag with desiccant sacks inside the bag. Adhesive tape was used to seal the polyethylene bag prior to clamping on the bolted ring closure. The AP used in the testing came from several different lots of material. Company analysis of each lot is presented in Appendix A.

The second test article was an aluminum bin with a volume of approximately 2.1 cubic meters (74 cubic feet). Five different top loading and top emptying bin designs are currently being used by the industry. Each is designed to meet the requirements of DOT Specification 56 and to contain amounts of AP in the range of 2045 to 2270 kilograms (4500 to 5000 pounds). Both rectangular and cylindrical bin designs are currently in use. This test program was performed using three of the bin designs rather than focusing on any one. The three designs used were the Morton-Thiokol Incorporated (MTI) cylindrical, the Atlantic Research Company (ARC) rectangular and the United Technologies-Chemical Systems Division (CSD) rectangular. Other aluminum bins with approximately the same AP capacity and having top loading and top emptying construction which meet requirements of DOT Specification 56 are addressed by analogy. In this test series significant test response differences between container designs were not noted. There was, however, a slight difference in the pressurization response of the various bins. The heavier construction of the CSD bins contained a higher pressure before failing. As a result the pressure rupture of the CSD bin tended to be slightly more violent with the ejection of more AP.

TEST TYPE 6 (a): SINGLE PACKAGE TEST

The type 6 (a) single package tests were performed in accordance with procedures in Section 42 of Reference 2 and with guidance provided in Reference 3. There were two basic tests performed under these procedures. The first was an initiation test which used a standard detonator as the initiation source. The standard detonator used for this test series was a number 8 blasting cap. An ignition source was used for the second test procedure. Here a dual squib igniter was used to ignite 57 g (2 ounces) of grade "FFF" black powder. Each source was placed at approximately the AP center within the test container. The

detonator/igniter also had a thermocouple secured one inch above it to measure AP pretest temperature and to ascertain functioning of the initiation/ignition source if the AP reaction provided no visible outside response. Three blasting cap and three black powder tests were required by Reference 3 for each test article.

Prior to placement of the initiation/ignition source, the test article, either a steel drum or aluminum bin, was set in position at the test location. Figures 1 and 2 show the test configuration for a steel drum. A special insertion tool was developed under this program to allow placement of the initiator/igniter near the center of the drum or bin without having to remove and replace large amounts of AP. The insertion tool was a combination guide tube and 2-inch diameter pointed rod. Figure 3 is a photo that shows the rod inserted in the aluminum tube. The disassembled insertion tool is shown in Figure 4. The actual penetration was accomplished by a combination of heavy downward pressure with both twisting and oscillating motions. During the process of developing this initiator/igniter insertion tool, several electrostatic measurements were obtained which confirmed there were no dangerous static ignition hazards created. Once the tool was located in the center of the drum or bin, the phenolic rod was removed from the inside of the aluminum tube, retaining the empty tube in the AP. The initiator or igniter assembly with its accompanying thermocouple was fed into the aluminum tube and the tube was then removed. As the tube was removed, the thermocouple and igniter/detonator wires were fed through it.

Sandbag confinement of nominally 0.6 meters (2 feet) was provided on all sides and the top for the steel drum tests. This was increased to a minimum of one meter (40 inches) for the larger aluminum bin tests. Sandbagging was not used on top of the bins because they are neither shipped nor stored with any material above them. The bin tests also included a thermocouple on the bottom and one centered on an outside panel. Instrumentation for each test included two piezo-electric microphones with threshold sensitivities of 0.2 Pascals (0.00003 psi) located 100 feet from the test article. Bikini (blow out paper) gauges were also used to detect overpressure, however, these gauges had lower thresholds sensitivities of 6890 Pascals (1.0 psi). They were positioned in two gauge lines 90 degrees apart and at distances of 30.5, 46, 61, 76, and 91 meters (100, 150, 200, 250, and 300 feet, respectively) from the test article. Twenty-four frames per second movie and thirty frames per second video coverages were provided by two documentation cameras and two video cameras. Two manually and remotely operated still cameras, 35 and 70 millimeter, were used for high definition photos at rates no greater than 3 frames per second. The instrumentation setup is shown in Figure 5.

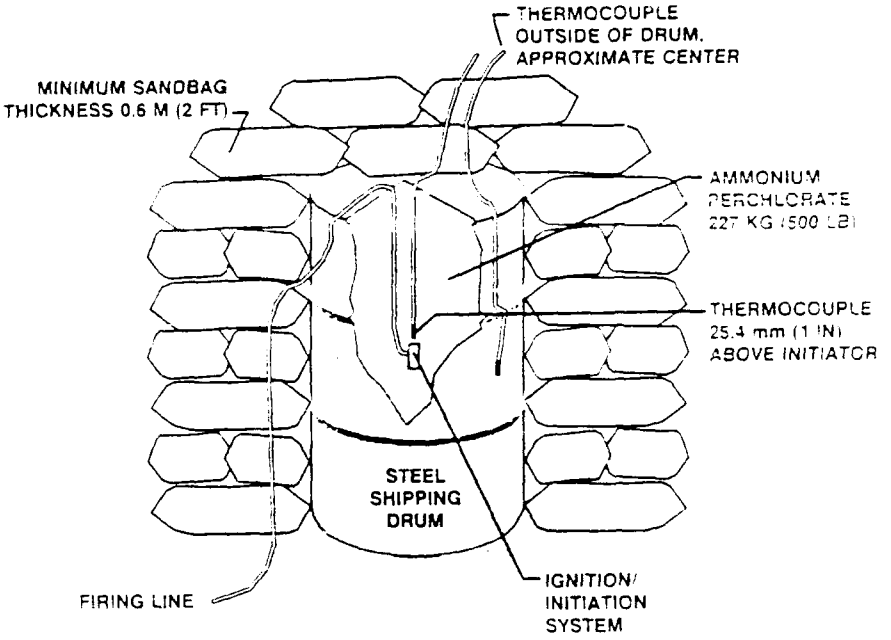


Figure 1. Single Package Test Configuration for Steel Drums

Figure 2. Typical Sandbag Confinement for Steel Drums

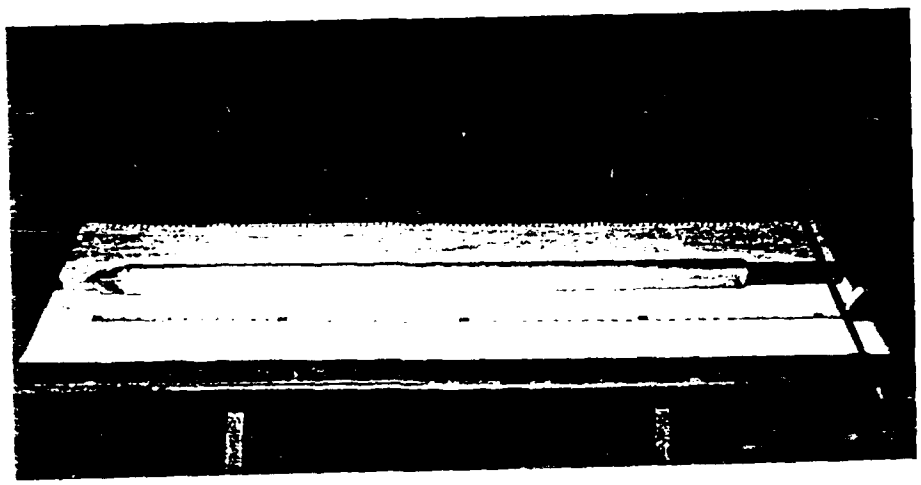


Figure 3. Insertion Tool in the Aluminum Guide Tube

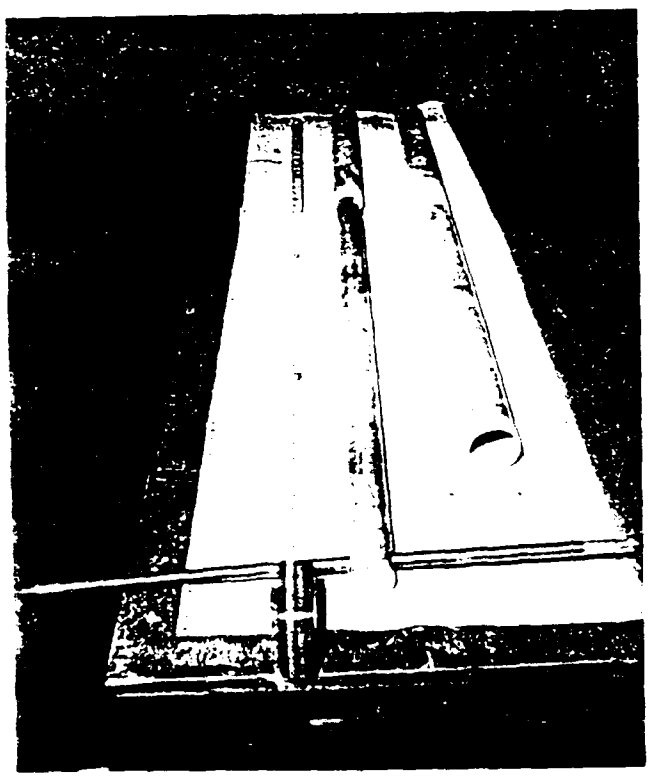


Figure 4. Insertion Tool Disassembled

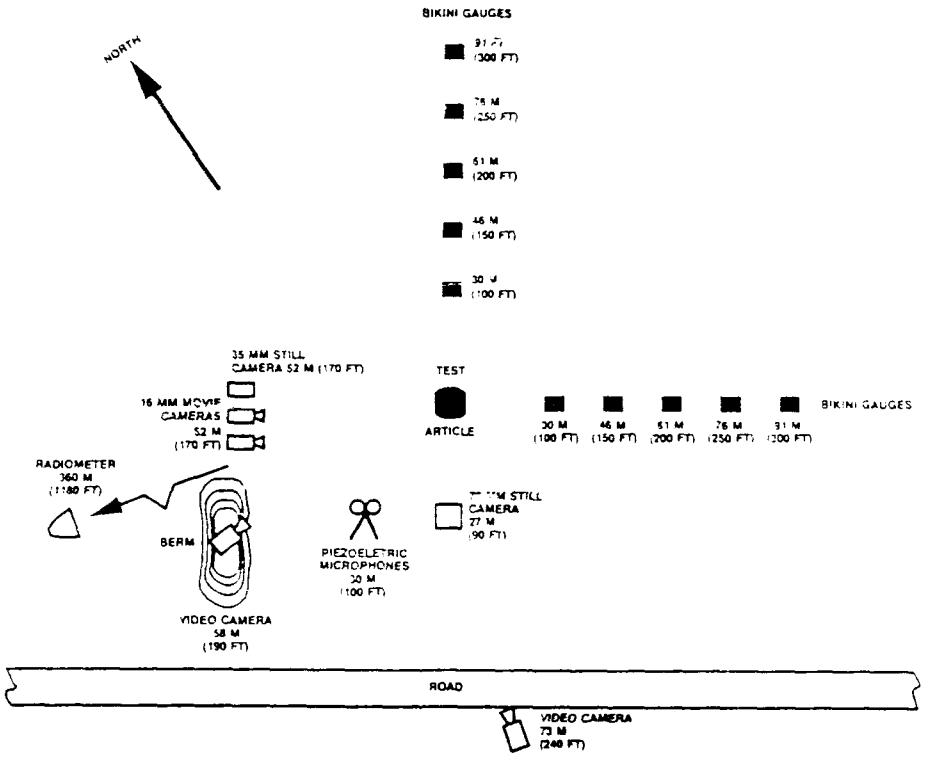


Figure 5. Instrumentation Layout

TEST TYPE 6 (b): STACK TEST

This test series was not required due to the lack of any explosive reactions in the type 6 (a), single package test.

TEST TYPE 6 (c): EXTERNAL FIRE (BONFIRE) TEST

The bonfire test was conducted in accordance with the procedures prescribed in Reference 2 Section 44 and guidance from Reference 3. The steel drum test was conducted at the AL, Edwards AFB CA. The aluminum bin test was conducted at the NWC, China Lake CA.

For the steel drum bonfire test five steel drums were placed on a steel support frame one meter above the ground. The test articles were then steel banded together (Figs. 6 and 7). Hardwood pallet pieces 1.2 meters (4 feet) long were cross-

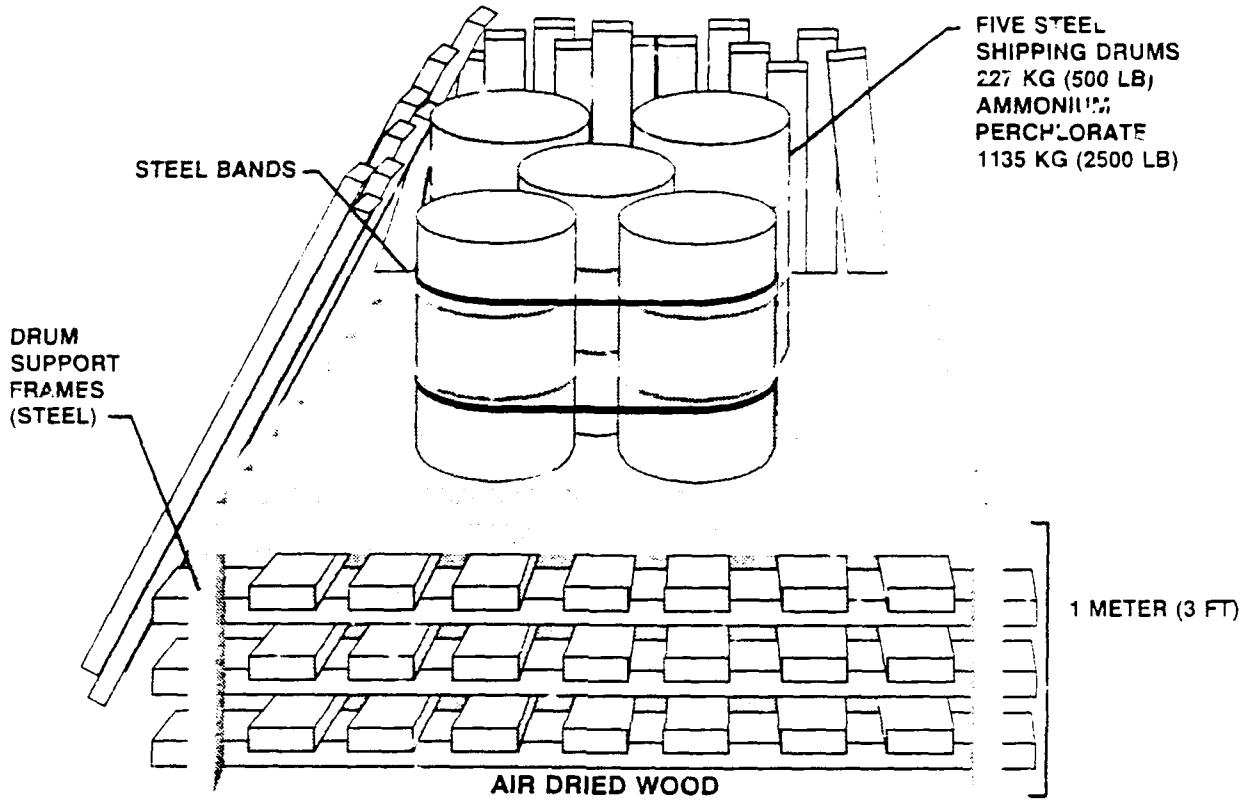


Figure 6. External Fire (Bonfire) Test Configuration for Steel Drums

Figure 7. Photograph of External Fire (Bonfire) Test Setup for Steel Drums

stacked to fill the volume under the support frame. The frame and drums were then surrounded by 51 by 102 mm (2 by 4 inch) by 2.4 meter (8 foot) lengths of softwood timbers leaning vertically four layers thick against the drum tops. The lower sections of lumber were then sprayed with 11 liters (3 gallons) of a diesel fuel and motor oil mixture (3 to 1 ratio). The base of the lumber was ignited remotely by 3 electric matches each in plastic bags containing 0.45 kg (1 lb) of aluminized class/division 1.3 solid propellant. Sixteen additional 2.5-cm (1-inch) cubes of propellant were distributed throughout the lower regions of the lumber to help assure rapid and uniform ignition. The blast instrumentation and movie/video coverage for the test were the same as for the type 6 (a), single package tests described above. Dual wide band radiometer sensors were added and located 360 meters (1180 feet) away to measure the radiant heat-time profile of the fire (Fig. 5). Thermocouples were located in the center and one perimeter drum. These thermocouples were placed on the top AP surface, inner bottom center and outer side wall of the drums.

The bonfire test of the aluminum bins was similar to that described for the drums. Five bins were supported one meter above the ground by a steel support frame. The volume below the support frame was filled with lengths of 51 by 102 mm (2 by 4 inch) by 2.4 meters (8 feet) lumber. The lumber was cross-stacked with approximately a board width spacing between lengths to allow ventilation (Fig. 8). An upper frame was built around the test stand after the bins were positioned to add initial stability to the perimeter stack of wood. Around the perimeter of the structure lengths of 51 by 102 mm (2 by 4 inch) by 3.0 meters (10 feet) lumber were used. The perimeter lumber was leaned against the frame in stacks 0.4 meters (15 inches) thick with a board width spacing between each stack. The four corners were left open for fuel placement and access to the interior. Rope was tied around the upper perimeter of the vertical lengths to add further stability in the event of winds common to the test site. Approximately 185 liters (50 gallons) of a 50 percent diesel fuel and 50 percent gasoline mixture were used to prime the lumber for ignition. About 150 liters (40 gallons) were spread internally through the four open corners, and the remaining 35 liters (10 gallons) were spread around the exterior vertical lengths. Ignition devices were placed in each of the four corners. Each igniting device consisted of a resistive wire wrapped inside a match book which was wrapped inside a gasoline soaked rag. The two ends of each igniter were energized by a 110 Volt A.C. source. The instrumentation layout for this test is presented in Figure 9. A radiometer was placed 185 meters (607 feet) away and centered on the stack. A total of 24 type K thermocouples (rated to 2500 degrees F) were used for this test. Ten thermocouples were positioned in the center bin (bin number 1) and 10 in one perimeter bin (bin number 2) as indicated in Figure 10. The four remaining thermocouples were positioned in the fire 1 meter (3 feet) above the test stand to measure the fire characteristics.

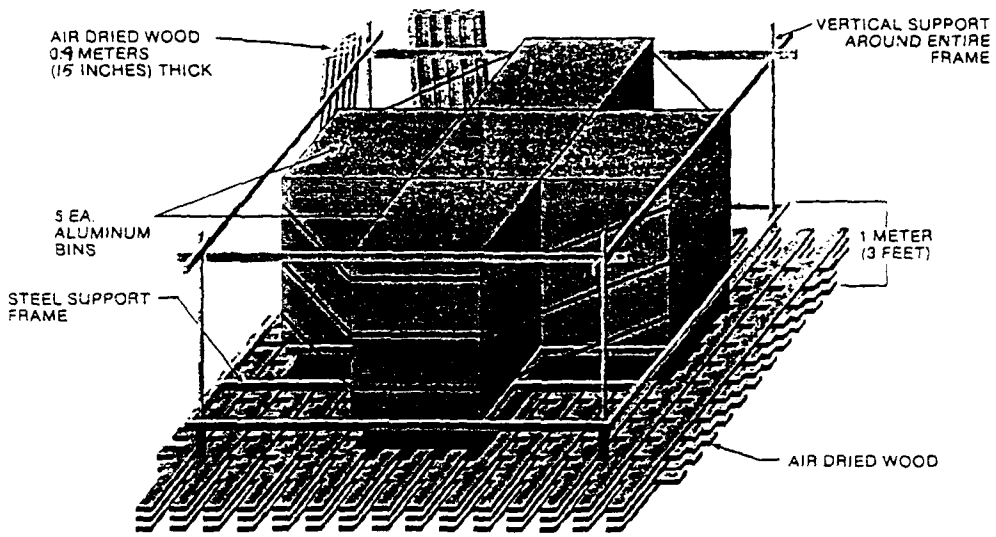


Figure 8. External Fire (Bonfire) Test Configuration for Aluminum Bins

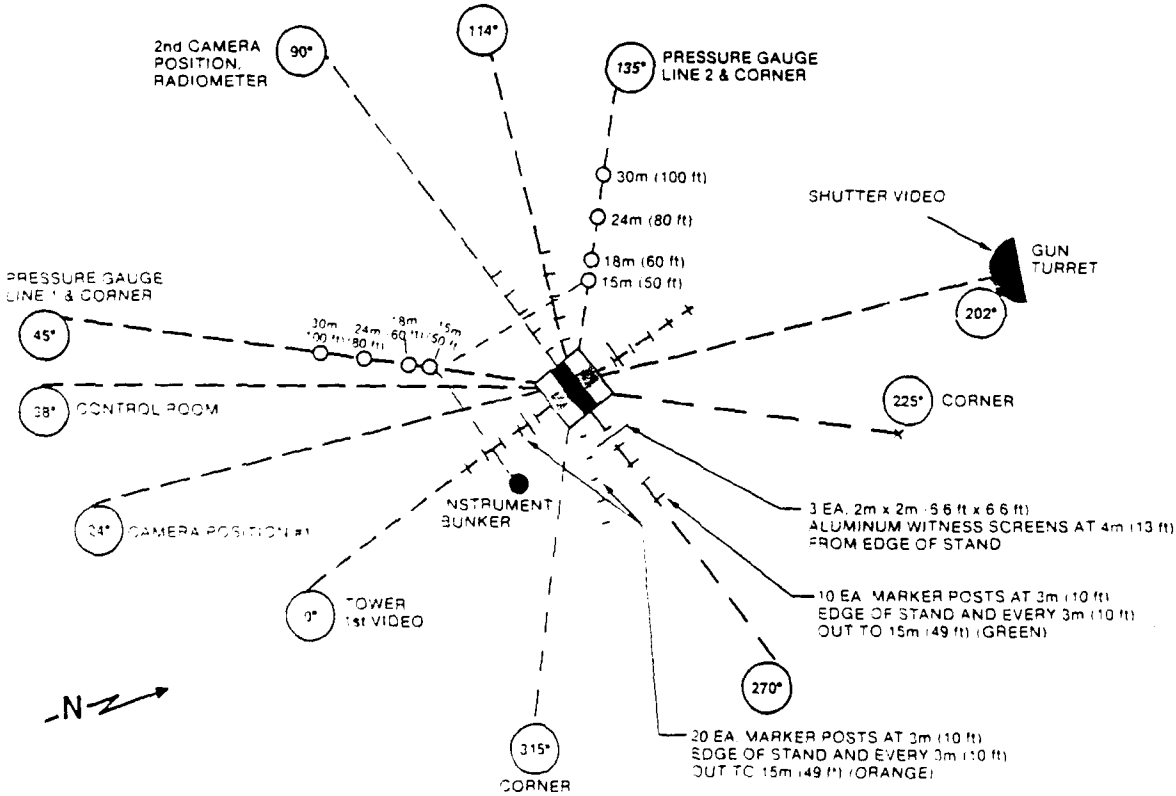
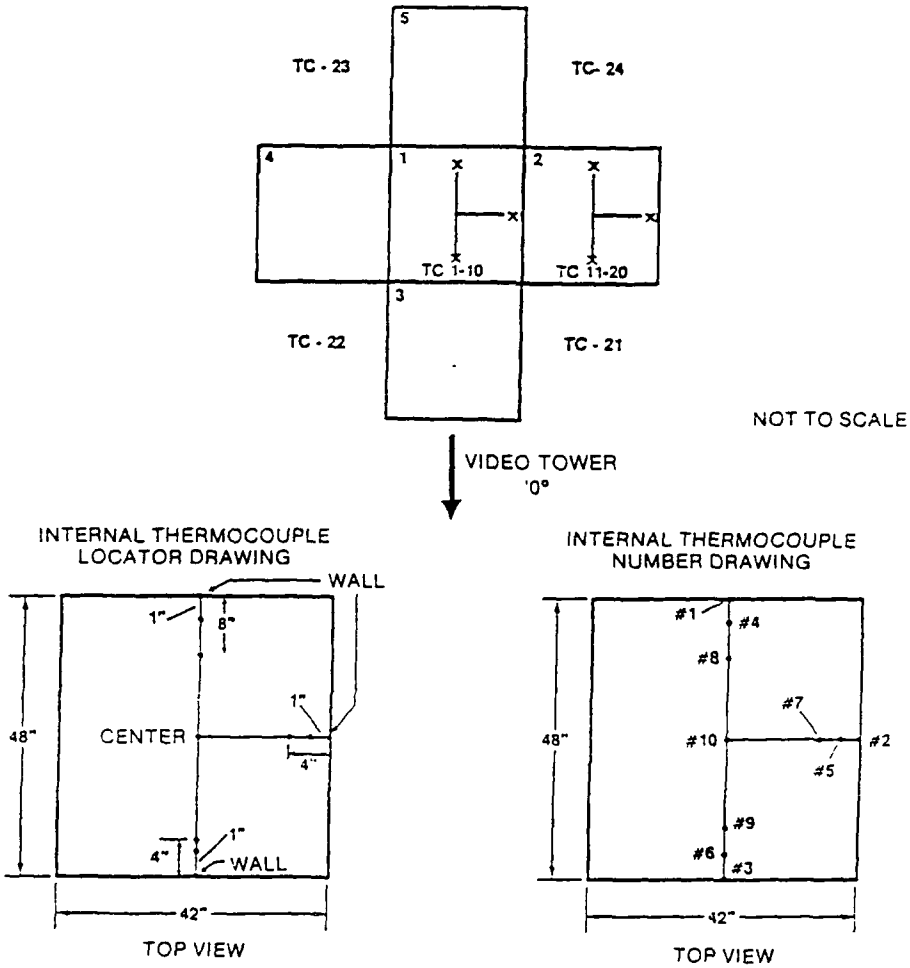


Figure 9. External Fire (Bonfire) Test Instrumentation for Aluminum Bins



BOTH BIN #1 & #2 HAD THE SAME ORIENTATION AND THERMOCOUPLE (TC) LOCATIONS. TC 11-20 WERE PLACED IN THE SAME SEQUENCE AS TC 1-10.

Figure 10. External Fire (Bonfire) Test Thermocouple Placement for Aluminum Bins

RESULTS: 227 kg (500 lb) STEEL DRUMS

The results of the steel drum series 6 tests are presented in Table 1. For the three single package cap tests the blasting cap functioned each time but only the 8 November 1988 test produced a visible response. In this test, after about a 42 second delay, the lid was ejected from the drum due to internal pressure but did not escape the sandbag coverage. AP within the drum decomposed slowly with an increasing rate of reddish-orange smoke evolution that ceased after about 28 minutes. All the AP was consumed and there was no explosion. The piezo-electric microphones did not detect measurable overpressure.

Table 1. RESULTS: 227 kg (500 lb) STEEL DRUM TESTS

Test Type	Stimulus	Sandbag Confinement	Results
6(a)	No. 8 blasting cap	>.5m	Slow burn for 28 min, drum body intact, no explosion.
6(a)	No. 8 blasting cap	>.5m	Cap functioned, no fire, no explosion.
6(a)	No. 8 blasting cap	>.5m	Cap functioned, no fire, no explosion.
6(a)	57g (2 oz) black powder	>.5m	Immediate fire response, slow burn for 33 min., no fragments, no explosion.
6(a)	57g (2 oz) black powder	>.5m	Immediate fire response, slow burn for 38 min., no fragments, no explosion.
6(a)	57g (2 oz) black powder	>.5m	Immediate fire response, slow burn for 43 min., no fragments, no explosion.
6(c)	Bonfire	N/A	Two drums ejected from the stack and fell not more than 1.2 m (4 ft) from the stand. One lid was thrown 21 m (70 ft) and another 6 m (20 ft) from the stand. Peak heat flux .07 cal/sq.cm/sec (2.8 kW/sq.m) @ 15 m (49 ft) corrected to 100 kg (220 lb) AP mass, fireball not beyond witness screens, flame jet not more than 3 m (10 ft) from flames, no explosion.

In each of the three black powder tests the drum lid was ejected immediately after ignition of the black powder charge. However, drum lids did not escape the sandbag covering. AP decomposed slowly with an increasing rate of reddish-orange smoke evolution similar to the one blasting cap test. Toward the end of the test, smoke evolution increased several fold and some flame was observed. The AP was completely consumed within 33 to 43 minutes after the initiating event. There were no explosions as indicated by the lack of measurable overpressure by the piezo-electric microphones.

During the bonfire test two of the five drums simultaneously burst out the bottom and top closures. These drums were thrown not more than 3 meters (10 feet) high and fell not more than 1.2 meters (4 feet) from the stand. Three drums were still on the support frame after the test. All AP was consumed in the fire except for about 45 kg (100 lb) which was thrown out on the ground around the stack. Thermocouple data for this test is provided in Appendix B. The piezo-electric microphones detected a miniscule overpressure event of 6.2 Pascals (0.001 psi). This overpressure does not indicate an explosive event. One drum lid ended up about 21 meters (70 feet) and another lid about 6 meters (20 feet) from the stack. The other three lids were closer to the fire event area. Radiometer readings corrected for the differences in range and mass indicated a heat flux of .07 cal/sq.cm/sec (2.8 kW/sq.m) at 15 meters for 100 kg (220 lb) of material. Examination of the photo and video coverages showed that the fireball did no extend beyond any of the three witness screens and that jets of flame did not extend more than 3 meters from the fire.

RESULTS: 2045 to 2270 kg (4500 to 5000 lb) ALUMINUM BINS

The results of the aluminum bin series 6 tests are presented in Table 2. For the three single package blasting cap tests the results were similar to those for the drums. In two tests the blasting caps fired, but no AP burned and there were, obviously, no explosions. In the other cap test the upper perimeter weld of the top panel fractured approximately 30 seconds after ignition of the blasting cap. The fill lid remained attached to the almost completely separated bin top. Rapid escape of pressure within the bin lifted the partially attached top of the bin onto the sandbags and tossed out approximately 45 kg (100 lb) of AP. The remaining AP decomposed by slow burning with reddish-orange smoke evolution lasting about 66 minutes. No explosive reaction occurred.

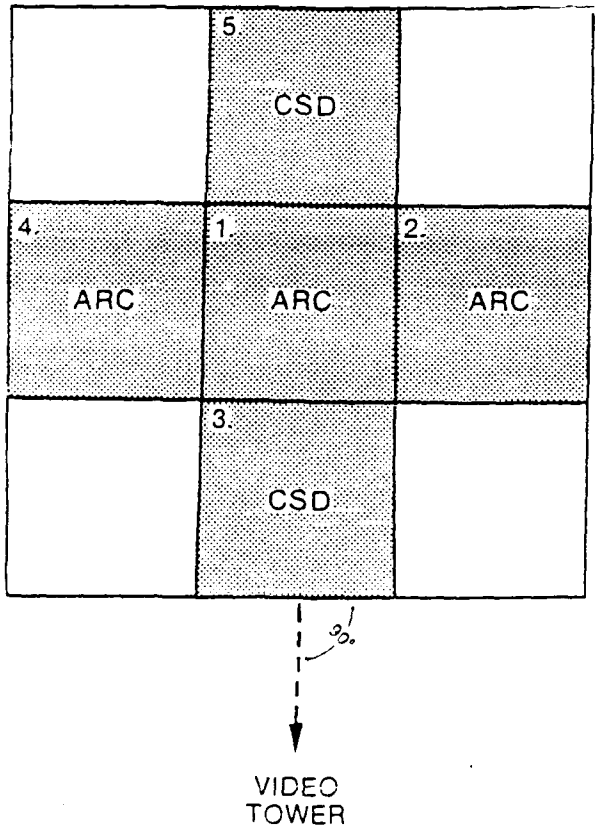
In the first two black powder tests, using Chemical Systems Division (CSD) bins, lids were ejected along with 114 kg and 182 kg (250 and 400 lb) of AP from 4 to 6 seconds after ignition of the black powder charge. Lids were thrown about 21 meters (70 ft) and 34 meters (110 ft). Flaming desiccant bags came out with

Table 2. RESULTS: 2045 to 2270 kg (4500 to 5000 lb) ALUMINUM BIN TESTS

Test Type	Stimulus	Sandbag Confinement	Results
6(a)	No. 8 blasting cap	>1 m	Slow burn for 1.1 hrs, ejected 45 kg (100 lb) AP, no explosion.
6(a)	No. 8 blasting cap	>1 m	Cap functioned, no fire, no explosion.
6(a)	No. 8 blasting cap	>1 m	Cap functioned, no fire, no explosion.
6(a)	57g (2 oz) black powder	>1 m	114 kg (250 lb) AP ejected, no fire, lid thrown 21 m (70 ft), no explosion.
6(a)	57g (2 oz) black powder	>1 m	182 kg (400 lb) AP ejected, lid thrown 34 m (110 ft), small 15 min fire on AP unburned, no explosion.
6(a)	57g (2 oz) black powder	>1 m	45 kg (100 lb) AP ejected, lid thrown 70 m (230 ft), no fire, no explosion.
6(c)	Bonfire	N/A	Intense AP burning complete in about four minutes, no hazardous fragments, fireball did not extend beyond witness screens, flame jet not more than 3 m from flames, no explosion.

the ejected AP and fell back onto the sandbags. In one of the tests this ignited the cloth sandbag material and created a short duration (10 to 15 min) minor fire. In these tests AP remaining in the containers was not consumed. During the last black powder test using a Morton Thiokol, Inc. (MTI) bin, at about 3 seconds after ignition of the black powder charge, the fill neck fractured throwing as a unit the sealing ring, clamp and lid about 70 meters (230 ft). Approximately 45 kg (100 lb) of AP was thrown out of the container. There was no sustained reaction or fire. The remaining 2000 kg (4400 lb) of AP was unburned.

The five aluminum bin bonfire test was conducted at the Naval Weapons Center (NWC), China Lake CA. All five of the bins were 2270 kg (5000 lb) capacity with three bins from ARC and the two remaining bins from CSD. The bin arrangement is shown in Figure 11 and the bin identification is presented in Table 3.



ARC – ATLANTIC RESEARCH CORPORATION BIN

CSD – UNITED TECHNOLOGIES CHEMICAL SYSTEMS DIVISION BIN

Figure 11. External Fire (Bonfire) Test Bin Arrangement for Aluminum Bins

Table 3. EXTERNAL FIRE (BONFIRE) TEST BIN IDENTIFICATION FOR ALUMINUM BINS

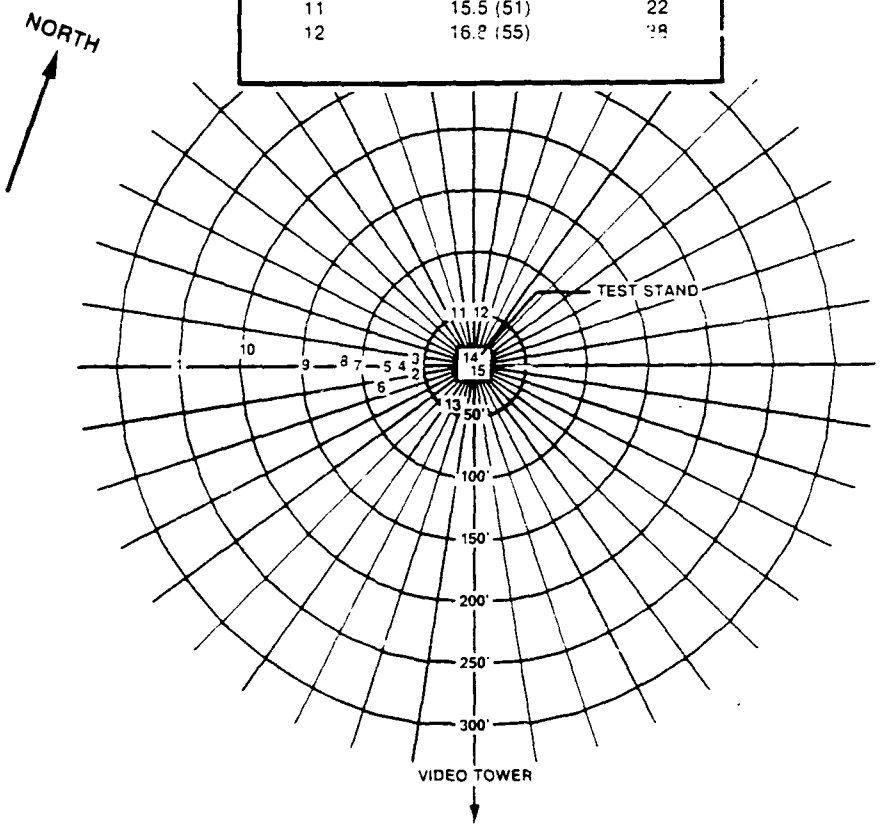
Position	Identification and Description
1	Atlantic Research Corporation Bin AR-658 Hoover Universal Tote Products DOT 56 Cap. 73 cubic feet, 5052 H-34 AL Top and Wall Thickness 0.110 inch, Bottom 0.250 inch AP-Kerr McGee Lot No. 7924
2	Atlantic Research Corporation Bin AR-479 Hoover Universal Tote Products DOT 56 Cap. 73 cubic feet, 5052 H-34 AL Top and Wall Thickness 0.110 inch, Bottom 0.250 inch AP-Kerr McGee Lot No. 7924
3	United Technologies-Chemical Systems Division Bin 059853 Fabrication Metal Inc. DOT 56 Cap. 74 cubic feet, 5052 H-32 AL Top and Wall Thickness 0.125 inch, Bottom 0.250 inch AP-Kerr McGee Lot No. 7665
4	Atlantic Research Corporation Bin AR-693 Hoover Universal Tote Products DOT 56 Cap. 73 cubic feet, 5052 H-34 AL Top and Wall Thickness 0.110 inch, Bottom 0.250 inch AP-Kerr McGee Lot No. 7924
5	United Technologies-Chemical Systems Division Bin 059862 Fabrication Metal Inc. DOT 56 Cap. 74 cubic feet, 5052 H-32 AL Top and Wall Thickness 0.125 inch, Bottom 0.250 inch AP-Kerr McGee Lot No. 7665

The radiometer was eliminated just prior to the test due to unstable operation. The test was initiated at 0915 on 6 Dec 1988. At approximately one minute and forty-eight seconds after ignition one of the bins ejected its lid and a substantial amount of AP. An intense AP burn followed that was complete in about four minutes. After the test only a small amount of AP was left scattered on the ground. A summary of the thermocouple data is presented in Appendix C. A total of 4.589 kilograms of aluminum was recovered from the bins original combined 657.72 kilograms. Figure 12 presents a fragment map of the surveyed area. A summary of these data as well as an analysis of each fragment is presented in Table 4. The first UN test criterion for fragments requires that no fragment with a mass of 150 grams or greater be thrown more than 15 meters. No fragment exceeded this first criterion. The second UN test criterion requires that not more than 10 fragments with a mass of 25 grams or greater be thrown a distance of 50 meters or greater. Only one fragment exceeded this 50 meter criterion, far short of the 10 specified. This one fragment was identified as witness screen material and did not belong to any of the test articles. Examination of the photo and video coverages showed that the fireball did not extend beyond any of the three witness screens and that jets of flame did not extend more than 3 meters from the flames of the fire. Lack of visible or overpressure sensory data indicates that no explosion occurred.

SUMMARY

This report provides a summary of transportation hazards tests completed by the Astronautics Laboratory and the Naval Weapons Center for certification of two ammonium perchlorate shipping container configurations. Specifically, the container configurations are 208 liter (55 gallon), 227 kilogram (500 pound) net weight AP, DOT specification 17H steel drums with bolted ring closure, and 2.1 cubic meters (74 cubic foot) aluminum bins containing from 2045 to 2270 kilograms (4500 to 5000 pounds) of material that conform to DOT Specification 56. The tests were conducted in accordance with the 1986 United Nations publication, "Recommendations on the Transportation of Dangerous Goods: Tests and Criteria," (ST/SG/AC.10/11). The results of the tests with propellant grade nominal 200-micron particle size ammonium perchlorate confirm the combination of the material and containers as being suitable for DOT hazard classification as an oxidizer with US DOT ID number UN1442.

FRAGMENT NUMBER	DISTANCE M (FT)	WEIGHT (GRAMS)
1	76.2 (250)	44
2	17.7 (58)	60
3	17.7 (58)	13
4	21.3 (70)	18
5	23.2 (76)	13
6	23.8 (78)	38
7	31.4 (103)	7
8	33.5 (110)	13
9	43.6 (143)	14
10	54.9 (180)	14
11	15.5 (51)	22
12	16.8 (55)	28



NOTATION POINT	DESCRIPTION
13	18' x 2' SWATH OF AP FROM 20' TO 38' OUT FROM TEST STAND
14	1.772 kg PIECE OF PARTIALLY MELTED ALUMINUM TOTE BIN, UNDER TEST STAND
15	2.523 kg MELTED ALUMINUM FROM TOTE BIN, UNDER TEST STAND

Figure 12. External Fire (Bonfire) Test Fragment Map for Aluminum Bins

Table 4. EXTERNAL FIRE (BONFIRE) TEST FRAGMENT SUMMARY AND ALANYSIS FOR ALUMINUM BINS

Fragment Number	Distance m (ft)	Weight grams	Thickness inches	Alloy	Source
1	76 (250)	44	0.090	6061	Witness Panels
2	18 (58)	60	0.124	5052	CSD Sidewall
3	18 (58)	13	0.124	5052	CSD Sidewall
4	21 (70)	18	0.114	5052	ARC Sidewall
5	23 (76)	13	0.123	5052	CSD Sidewall
6	24 (78)	38	0.090	6061	Witness Panels
7	31 (103)	7	0.124	5052	CSD Sidewall
8	34 (110)	13	0.123	5052	CSD Sidewall
9	44 (143)	14	0.089	6061	Witness Panels
10	55 (180)	14	0.089	6061	Witness Panels
11	16 (51)	22	0.108	5052	ARC Sidewall
12	17 (55)	38	0.113	5052	ARC Sidewall

REFERENCES

1. McIntyre, F.L., et alia, "Hazards Testing of Ammonium Perchlorate," ARLCD-CR-82026, May 1982.

2. United Nations, "Recommendations on the Transportation of Dangerous Goods: Tests and Criteria," (ST/SG/AC.10/11), first edition, 1986.

3. Ward, J., PhD, Guidance Memorandum from the Department of Defense Explosives Safety Board (DDESB), Sep 1988.

4. Department of The Air Force Technical Order, TO 11A-1-47, "Department of Defense Explosives Hazard Classification Procedures," March 1981.

APPENDIX A

LOT ANALYSIS OF AP USED IN TESTING

Kerr-McGee Lot Number 7893

Chemical Analysis (%)

Sample	A	A	B	B
Ash (H_2SO_4 treated)	0.23	0.28	0.28	0.27
Total Moisture	0.013	0.014	0.014	0.013
H_4ClO_4 Assay	99.3	99.2	99.2	99.2
TCP	0.15	0.15	0.16	0.16
pH	6.0	6.1	6.1	6.1

Screen Analysis (% Retained)

U.S. Sieve No.	A	A	B	B
48 Mesh	8.5	9.1	8.5	8.6
60 Mesh	23.1	23.8	22.8	22.9
65 Mesh	40.9	41.5	41.7	41.8
80 Mesh	54.7	55.4	54.2	54.6
100 Mesh	73.4	73.5	72.0	72.2
140 Mesh	91.0	91.1	90.2	90.2
200 Mesh	99.1	99.1	98.5	98.5

This AP was contained in all of the 500 pound net AP steel drum tests.

Kerr-McGee Lot Number 7716

Chemical Analysis (%)

Sample	A	B	C
Insoluble in Acid	0.002	0.002	0.002
Ash (H_2SO_4 treated)	0.22	0.27	0.22
Chlorates as NH_4ClO_3	0.007	0.007	0.007
Chlorides as NH_4Cl	0.008	0.006	0.008
Bromates as NH_4BrO_3	0.001	0.001	0.001
Fe_2O_3	0.0001	0.0001	0.0001
Moisture, (surface)	0.007	0.008	0.009
Total Moisture	0.026	0.025	0.028
NH_4ClO_4 Assay	99.4	99.4	99.4
Sodium and Potassium	0.03	0.03	0.03
TCP	0.16	0.170	0.17
pH	6.2	6.2	6.2

Screen Analysis (% Passing)

U.S. Sieve No.	A	B	C
40 Mesh	100.	100.	100.
50 Mesh	91.9	91.7	90.6
70 Mesh	61.7	60.5	39.4
100 Mesh	27.4	26.7	25.6
140 Mesh	8.9	8.8	7.9
200 Mesh	1.1	1.3	0.9

This AP was contained in three Morton Thiokol Incorporated bins. One bin was used in a 21 November 1988 blasting cap test and another In a 15 December 1988 blasting cap test. The last one was used in a 15 December 1988 black powder test.

PEPCON Lot Number 85034

Chemical Analysis (%)

Property/Sample	Composite I	Composite II
NH4ClO4 Assay	98.8	99.0
TCP	0.16	0.17
Total Water	0.05	0.05
pH	6.3	6.3
Sulphate Ash	0.24	0.25
Density, g/cubic in.	17.5	17.5

Screen Analysis (% Retained)

Tyler Sieve No.	Composite I	Composite II
35 Mesh	1	1
48 Mesh	7	7
65 Mesh	30	30
80 Mesh	50	49
100 Mesh	73	72
150 Mesh	94	93
200 Mesh	98	98

This AP was contained in three of the United Technologies-Chemical Systems Division Bins. One was used in a 12 December 1988 blasting cap test and another in a 13 December blasting cap test. The last was used in a 30 November 1988 black powder test.

Kerr-McGee Lot Number 7665

Chemical Analysis (%)

Sample	A	B	C
Water Insoluble	0.21	0.23	0.23
Ash (H_2SO_4 treated)	0.22	0.23	0.23
Chlorates as NH_4ClO_3	0.005	0.007	0.007
Chlorides as NH_4Cl	0.004	0.006	0.006
Fe_2O_3	0.0002	0.0002	0.0002
Moisture, (surface)	0.011	0.011	0.009
Total Moisture	0.029	0.027	0.035
NH_4ClO_4 Assay	99.5	99.5	99.5
Sodium and Potassium	0.03	0.03	0.03
TCP	0.20	0.22	0.22
pH	6.2	6.1	6.1

Screen Analysis (% Passing)

U.S. Sieve No.	A	B	C
50 Mesh	93.0	91.5	91.3
100 Mesh	28.8	29.9	28.4
140 Mesh	9.6	10.5	9.2

This AP was contained in the two United Technologies-Chemical Systems Division Bins used for the five bin external fire (Bonfire) test performed at the Naval Weapons Center, China Lake.

Kerr-McGee Lot Number 7924

Chemical Analysis (%)

Sample	
Insoluble in Acid	0.0038
Ash (H_2SO_4 treated)	0.25
Chlorates as NH_4ClO_3	0.003
Chlorides as NH_4Cl	0.010
Bromates as NH_4BrO_3	0.001
Moisture, (surface)	0.009
Total Moisture	0.018
NH_4ClO_4 Assay	99.3
Sodium and Potassium	0.0121
TCP	0.19
pH	6.3

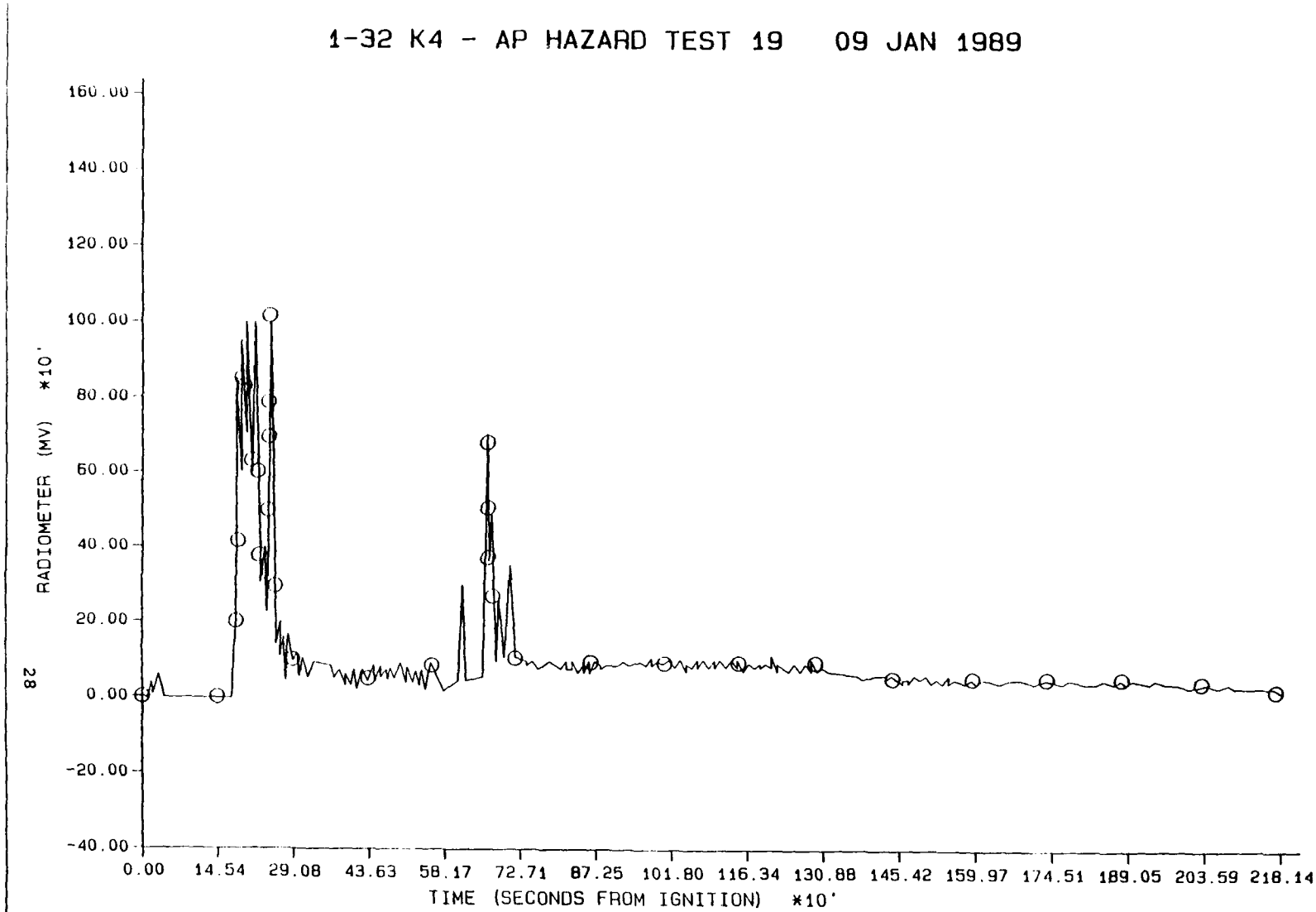
Screen Analysis (% Retained)

U.S. Sieve No.	
40 Mesh	0
50 Mesh	7.5
70 Mesh	38.1
100 Mesh	69.8
140 Mesh	90.0
200 Mesh	98.0

This AP was contained in the three Atlantic Research Corporation bins used for the five bin external fire (Bonfire) test performed at the Naval Weapons Center, China Lake.

APPENDIX B

THERMOCOUPLE AND RADIOMETER DATA FOR STEEL DRUM EXTERNAL FIRE (BONFIRE) TEST


1-32 K4 - AP HAZARD TEST 19 09 JAN 1989
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
-20.00
-40.00
RADIOMETER (MV) *10'
0.00
14.54
29.08
43.63
58.17
72.71
87.25
101.80
116.34
130.88
145.42
159.97
174.51
189.05
203.59
218.14
TIME (SECONDS FROM IGNITION) *10'

APPENDIX C

THERMOCOUPLE DATA FOR ALUMINUM BIN EXTERNAL FIRE (BONFIRE) TEST

APPENDIX C

Thermocouple Data for External Fire (Bonfire) Test of Five Aluminum Shipping Bins Each Containing Approximately 5000 Pounds of Ammonium Perchlorate

- Thermocouples 1-10 were located in Bin 1 (the center bin).
- Thermocouples 11-20 were located in Bin 2.
- Thermocouples 21-24 were located in the flame regions.
- See Figure 10 for individual thermocouple locations.

- The data for thermocouples 1-20 are presented in tabular form.
  - From t = 29 seconds (first appreciable temperature outside bins) until time ~ 2 minutes (vigorous outside reaction caused thermocouple disruption).
  - Time interval between columns is 0.5 seconds.
- The flame thermocouple data is presented in graphical form. The data after 2 minutes is unreliable.

CT4-1266 FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 001 DEGF	TC 001 DEGF	TC 001 DEGF	TC 001 DEGF	TC 001 DEGF	TC 001 DEGF	TC 001 DEGF	TC 001 DEGF	TC 001 DEGF	TC 001 DEGF
0	0	28 00	44	44	44	44	44	44	44	44	44	44
0	0	33 99	44	44	44	44	44	44	44	44	44	44
0	0	38 98	44	44	44	44	44	44	44	44	44	44
0	0	43 97	44	44	44	44	43	42	41	41	41	43
0	0	48 96	44	44	44	44	44	44	44	44	44	44
0	0	53 96	44	44	44	44	42	43	42	42	43	42
0	0	58 95	42	42	42	42	42	42	42	42	43	45
0	1	3 94	45	45	45	45	45	45	44	44	44	44
0	1	8 93	44	44	43	42	42	42	42	42	42	42
0	1	13 92	42	43	44	43	44	46	46	46	45	44
0	1	18 91	45	44	44	41	43	44	44	44	45	45
0	1	23 90	45	45	45	44	43	42	43	44	45	45
0	1	28 89	44	45	45	45	45	45	45	45	45	45
0	1	33 88	45	45	44	43	42	42	43	44	43	43
0	1	38 87	43	45	44	43	43	43	43	46	47	46
0	1	43 87	44	44	44	44	44	44	44	43	43	44
0	1	48 86	47	43	43	44	45	45	46	46	46	46
0	1	53 85	46	46	45	44	44	45	44	45	41	36
0	1	58 84	37	38	38	31	27	25	24	24	32	[illegible]
0	2	3 83	15	13	13	15	18	16	21	14	11	10

TIME IS FOR FIRST COLUMN OF TC 001 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0 50 SECONDS

CT4-1266 FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 002 DEGF	TC 002 DEGF	TC 002 DEGF	TC 002 DEGF	TC 002 DEGF	TC 002 DEGF	TC 002 DEGF	TC 002 DEGF	TC 002 DEGF	TC 002 DEGF
0	0	28 00	46	46	46	46	46	45	45	45	45	46
0	0	33 99	46	45	15	46	45	46	46	45	46	46
0	0	38 98	46	46	46	46	46	46	45	45	46	45
0	0	43 97	46	45	45	46	46	45	45	45	45	45
0	0	48 96	46	46	45	46	46	45	46	45	45	45
0	0	53 96	45	46	46	45	45	46	45	45	45	45
0	0	58 95	45	45	46	45	45	46	45	46	45	45
0	1	3 94	45	45	45	45	45	46	45	45	45	45
0	1	8 93	46	45	45	46	45	45	45	46	45	45
0	1	13 92	45	45	46	45	45	45	45	45	46	45
0	1	18 91	45	45	45	45	45	45	45	45	45	45
0	1	23 90	45	45	45	45	45	45	45	45	45	45
0	1	28 89	45	45	45	45	45	45	45	45	45	45
0	1	33 88	45	45	45	45	45	45	45	45	45	45
0	1	38 87	45	45	45	45	45	45	45	45	45	45
0	1	43 87	45	45	45	45	45	45	45	45	45	45
0	1	48 86	45	45	45	45	45	45	45	45	45	45
0	1	53 85	45	45	45	45	45	45	45	45	44	44
0	1	58 84	44	44	42	40	38	37	37	[illegible]	37	37
0	2	3 83	37	37	37	38	37	39	[illegible]	41	43	41
0	2	8 82	41	41	40	39	49	92	[illegible]	[illegible]	229	[illegible]

TIME IS FOR FIRST COLUMN OF TC 002 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0 50 SECONDS

CT4-12a6 FAST COOLOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 003 DEGF	TC 003 DEGF	TC 003 DEGF	TC 003 DEGF	TC 003 DEGF	TC 003 DEGF	TC 003 DEGF	TC 003 DEGF	TC 003 DEGF	TC 003 DEGF
0	0	29.00	45	45	45	45	45	45	45	45	45	45
0	0	33.99	45	45	45	45	45	45	45	45	45	45
0	0	38.98	45	45	45	45	45	45	45	45	45	45
0	0	43.97	45	45	45	45	45	45	45	45	45	45
0	0	48.96	45	45	45	45	45	45	45	45	45	45
0	0	53.96	45	45	45	45	45	45	45	45	45	45
0	0	58.95	45	45	45	45	45	45	45	45	45	45
0	1	3.94	45	45	45	45	45	45	45	45	45	45
0	1	8.93	45	45	45	45	45	45	45	45	45	45
0	1	13.92	45	45	45	45	45	45	45	45	45	45
0	1	18.91	45	44	45	45	45	45	44	45	44	45
0	1	23.90	45	44	45	45	44	45	44	45	45	44
0	1	28.89	44	44	45	45	45	44	45	44	45	44
0	1	33.88	44	44	44	44	44	44	45	44	44	45
0	1	38.87	45	45	45	45	45	46	46	46	46	46
0	1	43.87	46	46	46	46	46	46	46	46	46	47
0	1	48.86	51	47	45	45	44	44	43	43	43	44
0	1	53.85	45	44	44	44	44	44	44	44	44	45
0	1	58.84	41	39	38	34	33	30	31	31	31	32
0	2	3.83	33	34	50	60	50	51	61	71	79	84
0	2	8.82	92	103	114	122	129	145	163	176	181	172
0	2	13.81	117	107	91	84	78	74	62	55	30	8
0	2	18.80	-2									

TIME IS FOR FIRST COLUMN OF TC 003 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0.50 SECONDS

CT4-12a6 FAST COOLOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 004 DEGF	TC 004 DEGF	TC 004 DEGF	TC 004 DEGF	TC 004 DEGF	TC 004 DEGF	TC 004 DEGF	TC 004 DEGF	TC 004 DEGF	TC 004 DEGF
0	0	29.00	46	46	46	46	46	46	46	46	46	46
0	0	33.99	46	46	46	46	46	46	46	46	46	46
0	0	38.98	46	46	46	46	46	46	46	46	46	46
0	0	43.97	46	46	46	46	46	46	46	46	46	46
0	0	48.96	46	46	46	46	46	46	46	46	46	46
0	0	53.96	46	46	46	46	46	46	46	46	46	46
0	0	58.95	46	46	46	46	46	46	46	46	46	46
0	1	3.94	46	46	46	46	46	46	46	46	46	46
0	1	8.93	46	46	46	46	46	46	46	46	46	46
0	1	13.92	46	46	46	46	46	46	46	46	46	46
0	1	18.91	46	46	46	46	46	46	46	46	46	46
0	1	23.90	46	47	46	46	46	46	46	46	46	46
0	1	28.89	46	46	46	46	46	46	46	46	46	46
0	1	33.88	46	46	46	46	46	46	46	46	46	46
0	1	38.87	46	46	46	46	46	46	46	46	46	46
0	1	43.87	46	46	46	46	46	46	46	46	46	46
0	1	48.86	46	46	46	47	46	46	46	46	46	46
0	1	53.85	46	46	46	46	46	46	46	46	46	46
0	1	58.84	44	44	47	40	35	33	30	31	31	32
0	2	3.83	31	31	32	33	34	33	32	28	22	19
0	2	8.82	18	16	17	16	15	14	8	3		

TIME IS FOR FIRST COLUMN OF TC 004 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0.50 SECONDS

CT4-1266 FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 005 DEGF	TC 005 DEGF	TC 005 DEGF	TC 005 DEGF	TC 005 DEGF	TC 005 DEGF	TC 005 DEGF	TC 005 DEGF	TC 005 DEGF	TC 005 DEGF
0	0	29 00	47	47	47	47	47	47	47	47	47	47
0	0	33 99	47	47	47	47	47	47	47	47	47	47
0	0	38 98	47	47	47	47	47	47	47	47	47	47
0	0	43 97	47	47	47	47	47	47	47	47	47	47
0	0	48 96	47	47	47	47	47	47	47	47	47	47
0	0	53 96	47	47	47	47	47	47	47	47	47	47
0	0	58 95	47	47	47	47	47	47	47	47	47	47
0	1	3 94	47	47	47	47	47	47	47	47	47	47
0	1	8 93	47	47	47	47	47	47	47	47	47	47
0	1	13 92	47	47	47	47	47	47	47	47	47	47
0	1	18 91	47	47	47	47	47	47	47	47	47	47
0	1	23 90	47	47	47	47	47	47	47	47	47	47
0	1	28 89	47	47	47	47	47	47	47	47	47	47
0	1	33 88	47	47	47	47	47	47	47	47	47	47
0	1	38 87	47	47	47	47	47	47	47	47	47	47
0	1	43 87	47	47	47	47	47	47	47	47	47	47
0	1	48 86	47	47	47	47	47	47	47	47	47	47
0	1	53 85	47	47	47	47	47	47	47	47	47	47
0	1	58 84	46	45	45	45	46	46	46	46	45	45
0	2	3 83	44	44	43	41	40	38	33	29	29	30
0	2	8 82	31	29	25	19	13	9	0	-3		

TIME IS FOR FIRST COLUMN OF TC 005 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0 50 SECONDS

CT4-1266 FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 006 DEGF	TC 006 DEGF	TC 006 DEGF	TC 006 DEGF	TC 006 DEGF	TC 006 DEGF	TC 006 DEGF	TC 006 DEGF	TC 006 DEGF	TC 006 DEGF
0	0	29 00	49	49	49	49	49	49	49	49	49	49
0	0	33 99	49	49	49	49	49	49	49	49	49	49
0	0	38 98	49	49	48	49	49	49	49	49	49	49
0	0	43 97	49	49	49	49	49	49	49	49	49	49
0	0	48 96	49	49	49	49	49	49	49	49	49	49
0	0	53 96	49	49	49	49	49	49	49	49	49	49
0	0	58 95	49	49	49	49	49	49	49	49	49	49
0	1	3 94	49	49	49	49	49	49	49	49	49	49
0	1	8 93	49	49	49	49	49	49	49	49	49	49
0	1	13 92	49	49	49	49	49	49	49	49	49	49
0	1	18 91	49	49	49	49	49	49	49	49	49	49
0	1	23 90	49	49	49	49	49	49	49	49	49	49
0	1	28 89	49	49	49	49	49	49	49	49	46	49
0	1	33 88	49	49	49	49	49	49	49	49	49	49
0	1	38 87	49	49	49	49	49	49	49	49	49	49
0	1	43 87	49	49	49	49	49	49	49	49	49	49
0	1	48 86	49	49	49	49	49	49	49	49	49	49
0	1	53 85	49	49	49	49	49	49	49	48	47	48
0	1	58 84	43	42	42	44	43	38	23	0	-1	

TIME IS FOR FIRST COLUMN OF TC 006 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0 50 SECONDS

CT4-1266 FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 007 DEGF	TC 007 DEGF	TC 007 DEGF	TC 007 DEGF	TC 007 DEGF	TC 007 DEGF	TC 007 DEGF	TC 007 DEGF	TC 007 DEGF	TC 007 DEGF
0	0	29 00	50	50	50	50	50	50	50	50	50	50
0	0	33 99	50	50	50	50	50	50	50	50	50	50
0	0	38 98	50	50	50	50	50	50	50	50	50	50
0	0	43 97	50	50	50	50	50	50	50	50	50	50
0	0	48 96	50	50	50	50	50	50	50	50	50	50
0	0	53 96	50	50	50	50	50	50	50	50	50	50
0	0	58 95	50	50	50	50	50	50	50	50	50	50
0	1	3 94	50	50	50	50	50	50	50	50	50	50
0	1	8 93	50	50	50	50	50	50	50	50	50	50
0	1	13 92	50	50	50	50	50	50	50	50	50	50
0	1	18 91	50	50	50	50	50	50	50	50	50	50
0	1	23 90	50	50	50	50	50	50	50	50	50	50
0	1	28 89	50	50	50	50	50	50	50	50	50	50
0	1	33 88	50	50	50	50	50	50	50	50	50	50
0	1	38 87	50	50	50	50	50	50	50	50	50	50
0	1	43 87	50	50	50	50	50	50	50	50	50	50
0	1	48 86	50	50	50	50	50	50	50	50	50	50
0	1	53 85	50	50	50	50	50	50	50	50	50	49
0	1	58 84	49	49	49	48	48	48	47	47	47	46
0	2	3 83	46	44	42	41	40	38	33	31	26	25
0	2	8 82	30	26	24	24	23	18	3	-10		

TIME IS FOR FIRST COLUMN OF TC 007 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0 50 SECONDS

CT4-1266 FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 008 DEGF	TC 008 DEGF	TC 008 DEGF	TC 008 DEGF	TC 008 DEGF	TC 008 DEGF	TC 008 DEGF	TC 008 DEGF	TC 008 DEGF	TC 008 DEGF
0	0	29 00	51	51	52	51	51	51	51	51	51	51
0	0	33 99	51	51	51	51	51	51	51	51	51	51
0	0	38 98	51	51	51	52	51	51	52	51	51	51
0	0	43 97	51	51	51	51	51	51	51	51	51	51
0	0	48 96	51	51	51	51	51	51	51	51	51	51
0	0	53 96	51	51	51	51	51	52	51	51	51	51
0	0	58 95	51	51	51	51	51	51	51	51	51	51
0	1	3 94	51	51	51	51	51	51	51	51	51	51
0	1	8 93	51	51	51	51	51	51	51	51	51	51
0	1	13 92	51	51	51	51	51	51	51	51	51	51
0	1	18 91	52	51	51	51	51	51	51	51	51	51
0	1	23 90	51	51	51	51	51	51	51	51	51	51
0	1	28 89	51	51	51	51	51	51	52	51	51	51
0	1	33 88	51	51	51	51	51	51	52	51	51	51
0	1	38 87	51	51	51	51	51	51	51	51	51	51
0	1	43 87	51	51	51	52	51	51	51	51	51	51
0	1	48 86	51	51	51	51	51	51	51	51	51	51
0	1	53 85	51	51	51	51	51	52	51	51	51	51
0	1	58 84	50	48	46	47	43	43	42	46	44	43
0	2	3 83	39	35	30	31	31	27	18	11	9	10
0	2	8 82	14	11	10	7	1					

TIME IS FOR FIRST COLUMN OF TC 008 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0 50 SECONDS

CT4-12aa FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 009 DEGF	TC 009 DEGF	TC 009 DEGF	TC 009 DEGF	TC 009 DEGF	TC 009 DEGF	TC 009 DEGF	TC 009 DEGF	TC 009 DEGF	TC 009 DEGF
0	0	29 00	52	52	52	52	52	52	52	52	52	52
0	0	33 99	52	52	52	52	52	52	52	52	52	52
0	0	38 98	52	52	52	52	52	52	52	52	52	52
0	0	43 97	52	52	52	52	52	52	52	52	52	52
0	0	48 96	52	52	52	52	52	52	52	52	52	52
0	0	53 96	52	52	52	52	52	52	52	52	52	52
0	0	58 95	52	52	52	52	52	52	52	52	52	52
0	1	3 94	52	52	52	52	52	52	52	52	52	52
0	1	8 93	52	52	52	52	52	52	52	52	52	52
0	1	13 92	52	52	52	52	52	52	52	52	52	52
0	1	18 91	52	52	52	52	52	52	52	52	52	52
0	1	23 90	52	52	52	52	52	52	52	52	52	52
0	1	28 89	52	52	52	52	52	52	52	52	52	52
0	1	33 88	52	52	52	52	52	52	52	52	52	52
0	1	38 87	52	52	52	52	52	52	52	52	52	52
0	1	43 87	52	52	52	52	52	52	52	52	52	52
0	1	48 86	52	52	52	52	52	52	52	52	52	52
0	1	53 85	52	52	52	52	52	52	52	52	52	52
0	1	58 84	51	51	51	51	50	50	49	48	48	47
0	2	3 83	46	46	43	41	41	39	36	37	36	35
0	2	8 82	33	28	28	27	26	19	11	5	2	

TIME IS FOR FIRST COLUMN OF TC 009 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0.50 SECONDS

CT4-12aa FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 010 DEGF	TC 010 DEGF	TC 010 DEGF	TC 010 DEGF	TC 010 DEGF	TC 010 DEGF	TC 010 DEGF	TC 010 DEGF	TC 010 DEGF	TC 010 DEGF
0	0	29 00	54	54	54	54	54	54	54	54	54	54
0	0	33 99	54	54	54	54	54	54	54	54	54	54
0	0	38 98	54	54	54	54	54	54	54	54	54	54
0	0	43 97	54	54	54	54	54	54	54	54	54	54
0	0	48 96	54	54	54	54	54	54	54	54	54	54
0	0	53 96	54	54	54	54	54	54	54	54	54	54
0	0	58 95	54	54	54	54	54	54	54	54	54	54
0	1	3 94	54	54	54	54	54	54	54	54	54	54
0	1	8 93	54	54	54	54	54	54	54	54	54	54
0	1	13 92	54	54	54	54	54	54	54	54	54	54
0	1	18 91	54	54	54	54	54	54	54	54	54	54
0	1	23 90	54	54	54	54	54	54	54	54	54	54
0	1	28 89	54	54	54	54	54	54	54	54	54	54
0	1	33 88	54	54	54	54	54	54	54	54	54	54
0	1	38 87	54	54	54	54	54	54	54	54	54	54
0	1	43 87	54	54	54	54	54	54	54	54	54	54
0	1	48 86	54	54	54	54	54	54	54	54	54	54
0	1	53 85	54	54	54	54	54	54	54	54	54	54
0	1	58 84	52	52	51	50	50	50	49	48	48	47
0	2	3 83	50	49	47	50	49	47	45	44	45	44
0	2	8 82	45	44	44	44	44	43	42	41	38	37
0	2	13 81	23	20	12	5						

TIME IS FOR FIRST COLUMN OF TC 010 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0.50 SECONDS

CT4-12SA FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 011 DEGF	TC 011 DEGF	TC 011 DEGF	TC 011 DEGF	TC 011 DEGF	TC 011 DEGF	TC 011 DEGF	TC 011 DEGF	TC 011 DEGF	TC 011 DEGF
0	0	29.00	45	45	45	45	45	45	45	45	45	45
0	0	33.99	45	45	45	45	45	45	45	45	45	45
0	0	38.98	45	45	46	46	46	46	46	46	46	45
0	0	43.97	46	46	46	46	46	46	46	46	46	46
0	0	48.96	46	46	46	46	46	46	46	46	46	46
0	0	53.96	46	46	46	46	46	46	46	46	46	46
0	0	58.95	46	46	46	46	46	46	46	46	46	47
0	1	3.94	46	47	47	47	47	47	47	47	47	47
0	1	8.93	47	47	47	47	47	47	47	47	47	47
0	1	13.92	47	48	47	47	48	48	48	48	48	48
0	1	18.91	47	47	47	47	47	47	46	46	46	46
0	1	23.90	46	46	46	46	46	46	45	45	45	45
0	1	28.89	45	45	45	45	45	45	45	44	44	44
0	1	33.88	44	44	44	44	44	44	44	44	44	44
0	1	38.87	44	44	44	44	44	44	44	44	44	44
0	1	43.87	44	44	44	44	44	44	44	44	44	44
0	1	48.86	44	44	44	44	44	44	44	44	44	44
0	1	53.85	44	44	44	44	44	44	44	44	44	44
0	1	58.84	44	44	44	44	44	44	44	44	44	44
0	2	3.83	44	44	44	44	44	45	43	38	37	38
0	2	8.82	37	35	31	28	25	24	23	30	46	61
0	2	13.81	70	70	66	45	51	4	-49			

TIME IS FOR FIRST COLUMN OF TC 011 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0.50 SECONDS

CT4-12SA FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 012 DEGF	TC 012 DEGF	TC 012 DEGF	TC 012 DEGF	TC 012 DEGF	TC 012 DEGF	TC 012 DEGF	TC 012 DEGF	TC 012 DEGF	TC 012 DEGF
0	0	29.00	45	45	45	45	45	45	45	45	45	45
0	0	33.99	45	45	45	45	45	45	45	45	45	45
0	0	38.98	45	45	45	45	45	45	45	45	45	45
0	0	43.97	45	45	45	45	45	45	45	45	45	45
0	0	48.96	45	45	45	45	45	45	45	45	45	45
0	0	53.96	45	45	45	45	45	45	45	45	45	45
0	0	58.95	45	45	45	45	45	45	45	45	45	45
0	1	3.94	45	45	45	45	45	45	45	45	45	45
0	1	8.93	45	45	45	45	45	45	45	45	45	45
0	1	13.92	45	45	45	45	45	45	45	45	45	45
0	1	18.91	45	45	45	45	45	45	45	45	45	45
0	1	23.90	45	45	45	45	45	45	45	45	45	45
0	1	28.89	45	45	45	45	45	45	45	45	45	45
0	1	33.88	45	45	46	45	45	45	45	45	45	45
0	1	38.87	46	45	46	45	45	46	46	46	46	46
0	1	43.87	46	46	46	46	46	46	46	46	46	46
0	1	48.86	46	46	46	46	46	46	46	46	46	46
0	1	53.85	46	46	46	46	46	46	46	46	46	46
0	1	58.84	46	46	46	46	46	46	46	45	45	45
0	2	3.83	45	45	45	45	44	45	45	45	45	45
0	2	8.82	45	47	50	49	48	47	45	37	22	5

TIME IS FOR FIRST COLUMN OF TC 012 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0.50 SECONDS

CT4-1266 FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 013 DEGF	TC 013 DEGF	TC 013 DEGF	TC 013 DEGF	TC 013 DEGF	TC 013 DEGF	TC 013 DEGF	TC 013 DEGF	TC 013 DEGF	TC 013 DEGF
0	0	29.00	48	48	48	48	48	48	48	48	48	48
0	0	33.99	48	48	48	48	49	48	48	48	48	48
0	0	38.98	48	48	48	48	48	48	48	48	48	48
0	0	43.97	48	48	48	48	48	48	48	48	48	48
0	0	48.96	48	48	48	48	48	48	48	48	48	48
0	0	53.96	48	48	48	48	48	48	48	48	48	48
0	0	58.95	48	48	48	48	48	48	48	48	48	48
0	1	3.94	48	48	48	48	48	48	48	48	48	48
0	1	8.93	48	48	48	48	48	48	48	48	48	48
0	1	13.92	48	48	48	48	48	48	48	48	48	48
0	1	18.91	48	48	48	48	48	48	48	48	48	48
0	1	23.90	48	48	48	48	48	48	48	48	48	48
0	1	28.89	48	48	48	48	48	48	48	48	48	48
0	1	33.88	48	48	48	48	48	48	48	48	48	48
0	1	38.87	48	48	48	48	48	48	48	48	48	48
0	1	43.87	48	48	48	48	48	48	48	48	48	48
0	1	48.86	48	48	48	48	48	48	48	48	48	48
0	1	53.85	48	48	48	48	48	48	48	48	48	48
0	1	58.84	48	48	48	48	48	48	48	48	48	48
0	2	3.83	48	47	47	46	46	47	46	46	42	42
0	2	8.82	41	40	39	37	34	31	29	26	20	17
0	2	13.81	13	10	12	14	9	5	-2			

TIME IS FOR FIRST COLUMN OF TC 013 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0.50 SECONDS

CT4-1266 FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 014 DEGF	TC 014 DEGF	TC 014 DEGF	TC 014 DEGF	TC 014 DEGF	TC 014 DEGF	TC 014 DEGF	TC 014 DEGF	TC 014 DEGF	TC 014 DEGF
0	0	29.00	45	45	45	45	45	45	45	45	45	45
0	0	33.99	45	45	45	45	45	45	45	45	45	45
0	0	38.98	45	45	45	45	45	45	45	45	45	45
0	0	43.97	45	45	45	45	45	45	45	45	45	45
0	0	48.96	45	45	45	45	45	45	45	45	45	45
0	0	53.96	45	45	45	45	45	45	45	45	45	45
0	0	58.95	45	45	45	45	45	45	45	45	45	45
0	1	3.94	45	45	45	45	45	45	45	45	45	45
0	1	8.93	45	45	45	45	45	45	45	45	45	45
0	1	13.92	45	45	45	45	45	45	45	45	45	45
0	1	18.91	45	45	45	45	45	45	45	45	45	45
0	1	23.90	45	45	45	45	45	45	45	45	45	45
0	1	28.89	45	45	45	45	45	45	45	45	45	45
0	1	33.88	45	45	45	45	45	45	45	45	45	45
0	1	38.87	45	45	45	45	45	45	45	45	45	45
0	1	43.87	45	45	45	45	45	45	45	45	45	45
0	1	48.86	45	45	45	45	45	45	45	45	45	45
0	1	53.85	45	45	45	45	45	45	45	45	45	45
0	1	58.84	45	46	46	46	46	46	46	46	46	46
0	2	3.83	46	46	46	46	46	47	47	39	37	36
0	2	8.82	36	33	32	31	33	33	32	27	25	19
0	2	13.81	7	1	-1							

TIME IS FOR FIRST COLUMN OF TC 014 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0.50 SECONDS

CT4-12aa FAST COOKOFF WOOD AP 5 DEC 1988

TIME HOUR	MIN	SEC	TC 015 DEGF	TC 015 DEGF	TC 015 DEGF	TC 015 DEGF	TC 015 DEGF	TC 015 DEGF	TC 015 DEGF	TC 015 DEGF	TC 015 DEGF	TC 015 DEGF
0	0	29.00	45	45	45	45	45	45	45	45	45	45
0	0	33.99	45	45	45	45	45	45	45	45	45	45
0	0	38.98	45	45	45	45	45	45	45	45	45	45
0	0	43.97	45	45	45	45	45	45	45	45	45	45
0	0	48.96	45	45	45	45	45	45	45	45	45	45
0	0	53.96	45	45	45	45	45	45	45	45	45	45
0	0	58.95	45	45	45	45	45	45	45	45	45	45
0	1	3.94	45	45	45	45	45	45	45	45	45	45
0	1	8.93	45	45	45	45	45	45	45	45	45	45
0	1	13.92	45	45	45	45	45	45	45	45	45	45
0	1	18.91	45	45	45	45	45	45	45	45	45	45
0	1	23.90	45	45	45	45	45	45	45	45	45	45
0	1	28.89	45	45	45	45	45	45	45	45	45	45
0	1	33.88	45	45	45	45	45	45	45	45	45	45
0	1	38.87	45	45	45	45	45	45	45	45	45	45
0	1	43.87	45	45	45	45	45	45	45	45	45	45
0	1	48.86	45	45	45	45	45	45	45	45	45	45
0	1	53.85	45	45	45	45	45	45	45	45	45	45
0	1	58.84	45	45	45	45	45	45	45	45	45	45
0	2	3.83	45	45	44	44	44	45	43	41	40	39
0	2	8.82	36	32	28	24	20	17	16	9	3	

TIME IS FOR FIRST COLUMN OF TC 015 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0 50 SECONDS

CT4-12aa FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 016 DEGF	TC 016 DEGF	TC 016 DEGF	TC 016 DEGF	TC 016 DEGF	TC 016 DEGF	TC 016 DEGF	TC 016 DEGF	TC 016 DEGF	TC 016 DEGF
0	0	29.00	48	48	48	48	48	48	48	48	48	48
0	0	33.99	48	48	48	48	48	48	48	48	48	48
0	0	38.98	48	48	48	48	48	48	48	48	46	48
0	0	43.97	48	48	48	48	48	48	48	48	48	48
0	0	48.96	48	48	48	48	48	48	48	48	48	46
0	0	53.96	48	48	48	48	48	48	48	48	48	46
0	0	58.95	48	48	48	48	48	48	48	48	48	48
0	1	3.94	48	48	48	48	48	48	48	48	48	48
0	1	8.93	48	48	48	48	48	48	48	48	48	48
0	1	13.92	48	48	48	48	48	48	48	48	48	48
0	1	18.91	48	48	48	48	48	48	48	48	48	48
0	1	23.90	48	48	48	48	48	48	48	48	49	48
0	1	28.89	48	48	48	48	48	48	48	48	48	48
0	1	33.88	48	48	48	48	48	48	48	48	48	48
0	1	38.87	48	48	48	48	48	48	48	48	49	48
0	1	43.87	48	48	48	48	48	48	48	48	48	48
0	1	48.86	48	48	48	48	48	48	48	48	48	48
0	1	53.85	48	48	48	48	48	48	48	48	48	48
0	1	58.84	48	48	48	48	48	48	48	48	48	47
0	2	3.83	47	48	48	48	48	48	49	47	47	48
0	2	8.82	48	49	48	49	52	53	53	53	53	47
0	2	13.81	43	37	27	19						

TIME IS FOR FIRST COLUMN OF TC 016 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0 50 SECONDS

CT4-12aa FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 017 DEGF	TC 017 DEGF	TC 017 DEGF	TC 017 DEGF	TC 017 DEGF	TC 017 DEGF	TC 017 DEGF	TC 017 DEGF	TC 017 DEGF	TC 017 DEGF
0	0	29 00	49	49	49	49	49	49	49	49	49	49
0	0	33 99	49	49	49	49	49	49	49	49	49	49
0	0	38 98	49	49	49	49	49	49	49	49	49	49
0	0	43 97	49	49	49	49	49	49	49	49	49	49
0	0	48 96	49	49	49	49	49	49	49	49	49	49
0	0	53 96	49	49	49	49	49	49	49	49	49	49
0	0	58 95	49	49	49	49	49	49	49	49	49	49
0	1	3 94	49	49	49	49	49	49	49	49	49	49
0	1	8 93	49	49	49	49	49	49	49	49	49	49
0	1	13 92	49	49	49	49	49	49	49	49	49	49
0	1	18 91	49	49	49	49	49	49	49	49	49	49
0	1	23 90	49	49	49	49	49	49	49	49	49	49
0	1	28 89	49	49	49	49	49	49	49	49	49	49
0	1	33 88	49	49	49	49	49	49	49	49	49	49
0	1	38 87	49	49	49	49	49	49	49	49	49	49
0	1	43 87	49	49	49	49	49	49	49	49	49	49
0	1	48 86	49	49	49	49	49	49	49	49	49	49
0	1	53 85	49	49	49	49	49	49	49	49	49	49
0	1	58 84	49	49	49	49	49	49	49	49	49	49
0	2	3 83	63	62	59	59	58	63	67	73	77	80
0	2	8 82	87	92	98	100	105	110	119	125	132	139
0	2	13 81	127	126	130	133	127	144	155			

TIME IS FOR FIRST COLUMN OF TC 017 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0 50 SECONDS

CT4-12aa FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 018 DEGF	TC 018 DEGF	TC 018 DEGF	TC 018 DEGF	TC 018 DEGF	TC 018 DEGF	TC 018 DEGF	TC 018 DEGF	TC 018 DEGF	TC 018 DEGF
0	0	29 00	51	51	51	51	51	51	51	51	51	51
0	0	33 99	51	51	51	51	51	51	51	51	51	51
0	0	38 98	52	51	51	51	51	51	51	51	51	51
0	0	43 97	51	51	51	51	51	51	51	51	51	51
0	0	48 96	51	51	51	51	51	51	51	51	51	51
0	0	53 96	51	51	51	51	51	51	52	51	51	51
0	0	58 95	51	51	51	52	52	51	51	51	51	51
0	1	3 94	51	51	51	51	51	51	51	51	51	51
0	1	8 93	51	51	51	51	51	51	51	51	52	51
0	1	13 92	51	51	51	51	51	51	51	51	51	51
0	1	18 91	51	51	51	51	51	51	51	51	51	51
0	1	23 90	51	51	51	51	51	51	51	51	51	51
0	1	28 89	51	51	51	51	51	51	51	51	51	51
0	1	33 88	51	51	51	51	51	51	51	51	51	51
0	1	38 87	51	51	51	51	51	51	51	51	51	51
0	1	43 87	51	51	51	51	51	51	51	51	51	51
0	1	48 86	51	51	51	51	51	51	51	51	51	51
0	1	53 85	52	51	51	51	51	51	51	51	51	51
0	1	58 84	51	51	51	51	51	51	51	51	51	51
0	2	3 83	51	50	50	50	50	50	51	51	51	55
0	2	8 82	52	52	51	51	48	49	52	58	63	69
0	2	13 81	67	56	48	51	62	63	80			

TIME IS FOR FIRST COLUMN OF TC 018 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0 50 SECONDS

CT4-1266 FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 019 DEGF	TC 019 DEGF	TC 019 DEGF	TC 019 DEGF	TC 019 DEGF	TC 019 DEGF	TC 019 DEGF	TC 019 DEGF	TC 019 DEGF	TC 019 DEGF
0	0	29.00	51	51	51	51	51	51	51	51	51	51
0	0	33.99	51	51	51	51	51	51	51	51	51	51
0	0	38.98	51	51	51	51	51	51	51	51	51	51
0	0	43.97	51	51	51	51	51	51	51	51	51	51
0	0	48.96	51	51	51	51	51	51	51	51	51	51
0	0	53.96	51	51	51	51	51	51	51	51	51	51
0	0	58.95	51	51	51	51	51	51	51	51	51	51
0	1	3.94	51	51	51	51	51	51	51	51	51	51
0	1	8.93	51	51	51	51	51	51	51	51	51	51
0	1	13.92	51	51	51	51	51	51	51	51	51	51
0	1	18.91	51	51	51	51	51	51	51	51	51	51
0	1	23.90	51	51	51	51	51	51	51	51	51	51
0	1	28.89	51	51	51	51	51	51	51	51	51	51
0	1	33.88	51	51	51	51	51	51	51	51	51	51
0	1	38.87	51	51	51	51	51	51	51	51	51	51
0	1	43.87	51	51	51	51	51	51	51	51	51	51
0	1	48.86	51	51	51	51	51	51	51	51	51	51
0	1	53.85	51	51	51	51	51	51	51	51	51	51
0	1	58.84	51	51	51	51	51	51	51	51	51	51
0	2	3.83	50	50	50	50	49	49	50	48	48	49
0	2	8.82	49	49	48	46	44	42	42	39	35	27
0	2	13.81	13	6	8	6						

TIME IS FOR FIRST COLUMN OF TC 019 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0.50 SECONDS

CT4-1266 FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 020 DEGF	TC 020 DEGF	TC 020 DEGF	TC 020 DEGF	TC 020 DEGF	TC 020 DEGF	TC 020 DEGF	TC 020 DEGF	TC 020 DEGF	TC 020 DEGF
0	0	29.00	54	54	54	54	54	54	54	54	54	54
0	0	33.99	54	54	54	54	54	54	54	54	54	54
0	0	38.98	54	54	54	54	54	54	54	54	54	54
0	0	43.97	54	54	54	54	54	54	54	54	54	54
0	0	48.96	54	55	54	54	54	54	54	54	54	54
0	0	53.96	54	54	54	54	54	54	54	54	54	54
0	0	58.95	54	54	54	54	54	54	54	54	54	54
0	1	3.94	54	54	54	54	54	54	54	54	54	54
0	1	8.93	54	54	54	54	54	54	54	54	54	54
0	1	13.92	54	54	54	54	54	54	54	54	54	54
0	1	18.91	54	54	54	54	54	54	54	54	54	54
0	1	23.90	54	54	54	54	54	54	54	54	54	54
0	1	28.89	54	54	54	54	54	54	54	54	54	54
0	1	33.88	54	54	54	54	54	54	54	54	54	54
0	1	38.87	54	54	54	54	54	54	54	54	54	54
0	1	43.87	54	54	54	54	54	54	54	54	54	54
0	1	48.86	54	54	54	54	54	54	54	54	54	54
0	1	53.85	54	54	54	54	54	54	54	54	54	54
0	1	58.84	54	54	54	54	54	54	54	54	54	54
0	2	3.83	54	54	54	53	53	53	53	53	54	54
0	2	8.82	54	54	55	54	53	53	53	51	50	49
0	2	13.81	48	49	52	54	55	54	48	37	37	34
0	2	18.80	27	36	30	23	25	34	35	48	61	66
0	2	23.79	36									

TIME IS FOR FIRST COLUMN OF TC 020 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0.50 SECONDS

CT4-1288 FAST COOKOFF NOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 021 DEGF	TC 021 DEGF	TC 021 DEGF	TC 021 DEGF	TC 021 DEGF	TC 021 DEGF	TC 021 DEGF	TC 021 DEGF	TC 021 DEGF	TC 021 DEGF
0	-1	0.00	45	46	46	46	46	46	46	46	46	46
0	0	-55.01	46	46	46	46	46	46	46	46	46	46
0	0	-50.02	46	46	46	46	46	46	46	46	46	46
0	0	-45.03	46	46	46	46	46	46	46	46	46	46
0	0	-40.04	46	46	46	46	46	46	46	46	46	46
0	0	-35.04	46	46	46	46	46	46	46	46	46	46
0	0	-30.05	46	46	46	46	46	46	46	46	46	46
0	0	-25.06	46	46	46	46	46	46	46	46	46	46
0	0	-20.07	46	46	46	46	46	46	46	46	46	46
0	0	-15.08	46	46	46	46	46	46	46	46	46	46
0	0	-10.09	46	46	46	46	46	46	46	46	46	46
0	0	-5.10	46	46	46	46	46	46	46	46	46	46
0	0	-0.11	46	46	46	46	46	46	46	46	46	46
0	0	4.88	46	46	46	46	46	46	46	46	46	46
0	0	9.87	46	46	46	46	46	46	46	46	46	46
0	0	14.87	46	46	46	46	46	47	46	47	47	47
0	0	19.86	47	47	47	47	47	47	47	47	47	47
0	0	24.85	47	47	47	47	47	47	47	47	47	47
0	0	29.84	47	47	47	47	47	47	47	47	47	47
0	0	34.83	47	47	47	47	47	47	47	47	47	48
0	0	39.82	47	47	47	47	47	48	48	48	48	48
0	0	44.81	48	48	48	48	48	48	48	48	48	48
0	0	49.80	48	48	48	48	48	48	48	48	49	49
0	0	54.79	49	49	49	49	49	49	49	49	49	49
0	0	59.78	49	49	49	49	49	50	50	50	50	50
0	1	4.78	50	50	51	51	51	51	51	51	52	52
0	1	9.77	52	52	53	53	53	53	53	53	54	54
0	1	14.76	54	54	55	55	55	55	56	56	56	56
0	1	19.75	56	57	57	57	57	58	58	58	58	59
0	1	24.74	59	58	58	58	58	59	59	60	60	60
0	1	29.73	60	61	61	61	61	61	61	61	62	62
0	1	34.72	62	62	62	62	63	63	63	64	64	65
0	1	39.71	65	65	66	66	66	66	67	67	67	68
0	1	44.70	68	68	69	69	69	69	69	69	70	70
0	1	49.69	70	75	88	92	94	99	102	104	106	109
0	1	54.69	110	112	114	116	118	120	121	146	162	167
0	1	59.68	177	191	272	349	408	582	727	836	901	931
0	2	4.67	949	975	1009	1025	1037	1104	1119	1098	1103	1147
0	2	9.66	1179	1206	1233	1267	1296	1322	1326	1330	1372	1404
0	2	14.65	1415	1409	1376	1336	1303	1293	1286	1272	1298	1321
0	2	19.64	1396	1557	2256	2975	3292	3402	3802	3802	3802	3802
0	2	24.63	3802	3802	3802	3802	3802	3797	3653	3306	3065	2926
0	2	29.62	2862	2988								

TIME IS FOR FIRST COLUMN OF TC 021 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0.50 SECONDS

CTA 1258 FAST COOKOFF WOOD AP 6 DEC 1988

TIME HOUR	MIN	SEC	TC 022 DEGF	TC 022 DEGF	TC 022 DEGF	TC 022 DEGF	TC 022 DEGF	TC 022 DEGF	TC 022 DEGF	TC 022 DEGF	TC 022 DEGF	TC 022 DEGF
0	-1	0 00	46	46	46	46	46	46	46	46	46	46
0	0	-55 01	46	46	46	46	46	46	46	46	46	46
0	0	-50 02	46	46	46	46	46	46	46	46	46	46
0	0	-45 03	46	46	46	46	46	46	46	46	46	46
0	0	-40 04	46	46	46	46	46	46	46	46	46	46
0	0	-35 04	46	46	46	46	46	46	46	46	46	46
0	0	-30 05	46	46	46	46	46	46	46	46	46	46
0	0	-25 06	46	46	46	46	46	46	46	46	46	46
0	0	-20 07	46	46	46	46	46	46	46	46	46	46
0	0	-15 08	46	46	46	46	46	46	46	46	46	46
0	0	-10 09	46	46	46	46	46	46	46	46	46	46
0	0	-5 10	46	46	46	46	46	46	46	46	46	46
0	0	-0 11	46	46	46	46	46	46	46	46	46	47
0	0	4 86	47	47	47	47	48	48	48	49	49	50
0	0	9 87	50	50	50	51	51	52	52	52	53	53
0	0	14 87	53	54	54	54	54	55	55	55	55	55
0	0	19 86	55	55	55	55	55	55	55	56	56	56
0	0	24 85	56	56	56	56	56	56	56	56	57	57
0	0	29 84	57	57	57	57	57	58	58	58	58	58
0	0	34 83	58	58	58	58	59	59	59	59	59	59
0	0	39 82	60	60	60	60	60	60	60	61	63	65
0	0	44 81	68	70	72	76	82	84	85	88	89	90
0	0	49 80	94	97	101	106	109	112	116	122	128	133
0	0	54 79	138	140	143	148	152	156	160	164	169	175
0	0	59 78	181	185	193	202	209	216	226	239	258	284
0	1	4 78	366	441	499	607	698	826	895	965	1060	1140
0	1	9 77	1195	1224	1288	1382	1447	1464	1464	1454	1444	1451
0	1	14 76	1428	1420	1459	1519	1548	1605	1640	1685	1701	1723
0	1	19 75	1746	1776	1799	1818	1794	1786	1825	1824	1846	1848
0	1	24 74	1842	1831	1825	1834	1850	1862	1861	1837	1815	1841
0	1	29 73	1860	1866	1880	1887	1883	1898	1903	1910	1901	1924
0	1	34 72	1946	1962	1966	1968	1960	1949	1931	1926	1913	1929
0	1	39 71	1933	1938	1957	1944	1940	1928	1933	1932	1916	1996
0	1	44 70	1884	1887	1898	1900	1917	1928	1935	1950	1964	1970
0	1	49 69	1901	1944	2084	2269	2366	2370	2411	2484	2497	2483
0	1	54 69	2449	2376	2208	2074	2017	1932	1872	1789	1635	1509
0	1	59 68	1425	1370	1362	1567	1832	2216	1158	1054	1051	-2639
0	2	4 67	-6264	-4204	477	1367	803	1147	1185	1345	1398	1330
0	2	9 66	1309	1344	1229	1337	1337	1372	1345	1317	1324	1358
0	2	14 65	1383	1066	1480	1887	1385	1626	2582	2668	2513	2349
0	2	19 64	2147	2011	2159	2207	1940	1892	2059	2316	2477	2458
0	2	24 63	2410	2248	2904	3661	3802	3349	3802	3802	3632	3590
0	2	29 62	3802	3802								

TIME IS FOR FIRST COLUMN OF TC 022 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0 50 SECONDS

CTA 1256 FAST COOLOFF WOOD AP 6 DEC 1988

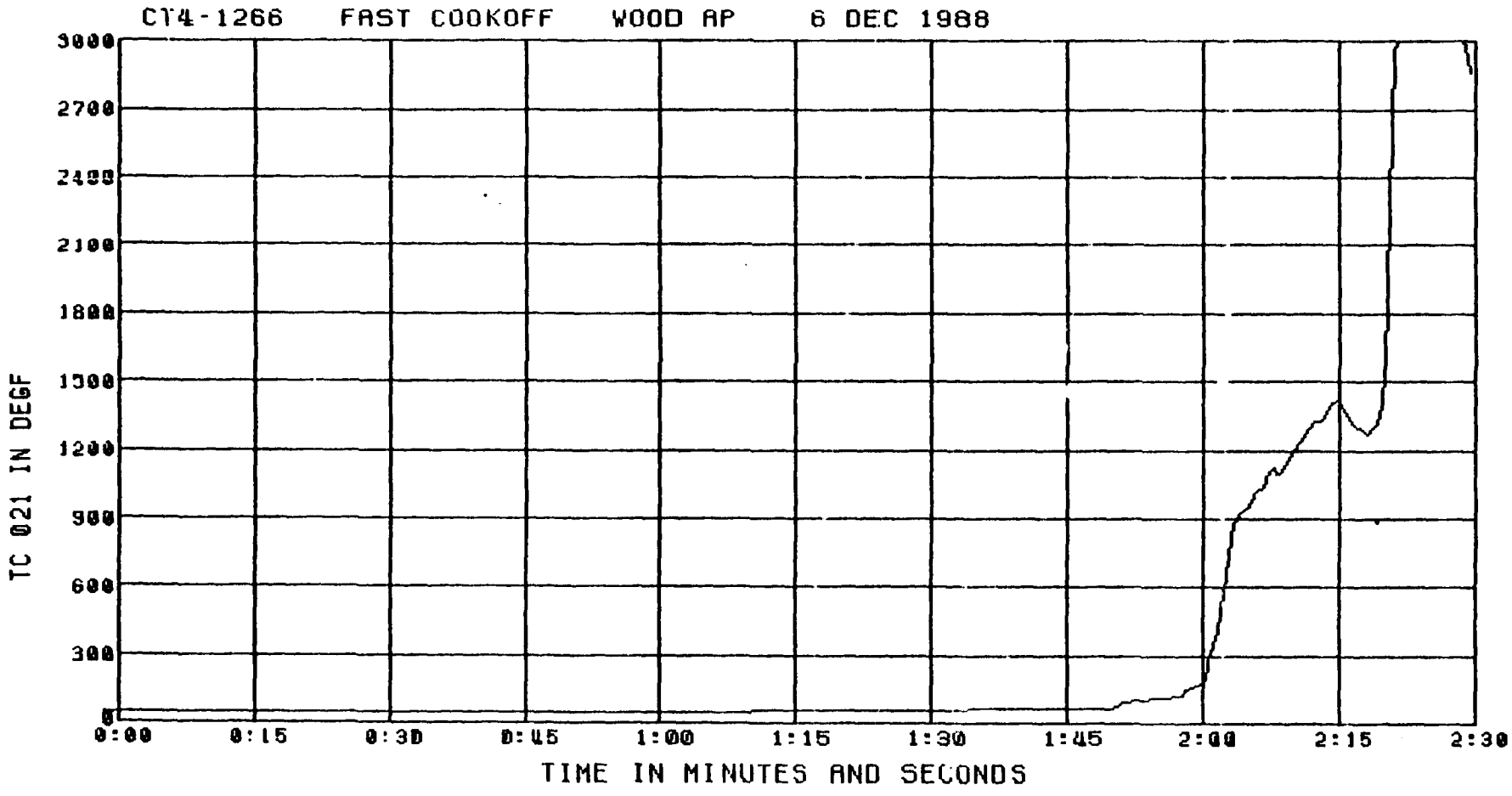
TIME HOUR	MIN	SEC	TC 023 DEGF	TC 023 DEGF	TC 023 DEGF	TC 023 DEGF	TC 023 DEGF	TC 023 DEGF	TC 023 DEGF	TC 023 DEGF	TC 023 DEGF	TC 023 DEGF
0	-1	0.00	47	46	46	46	46	46	46	46	4	46
0	0	-55.01	46	46	46	46	46	46	46	46	46	46
0	0	-50.02	46	46	46	46	46	46	46	46	46	46
0	0	-45.03	46	46	46	46	46	46	47	46	47	46
0	0	-40.04	46	46	47	46	46	47	47	46	46	47
0	0	-35.04	47	46	47	47	47	47	47	47	47	47
0	0	-30.05	47	47	47	47	47	47	47	47	47	47
0	0	-25.06	47	47	47	47	47	47	46	46	46	47
0	0	-20.07	46	46	46	46	46	46	46	46	4	46
0	0	-15.08	46	46	46	46	46	46	46	47	4	47
0	0	-10.09	47	47	47	47	47	47	46	47	4	47
0	0	-5.10	47	47	47	47	46	47	46	47	4	47
0	0	-0.11	47	47	47	47	47	47	47	47	47	47
0	0	4.88	47	48	48	48	48	48	49	49	49	49
0	0	9.87	49	50	50	50	50	51	51	51	51	52
0	0	14.87	52	53	53	53	54	54	55	57	58	60
0	0	19.86	62	65	67	68	70	71	72	73	74	75
0	0	24.85	76	76	76	76	77	78	78	79	80	80
0	0	29.84	81	81	82	83	85	87	90	103	113	118
0	0	34.83	127	136	149	174	215	241	292	396	527	697
0	0	39.82	838	1017	1140	1214	1263	1353	1432	1479	1472	1475
0	0	44.81	1462	1483	1534	1579	1631	1658	1693	1721	1765	1793
0	0	49.80	1827	1859	1876	1889	1895	1909	1900	1906	1902	1895
0	0	54.79	1893	1908	1917	1928	1896	1867	1847	1842	1836	1871
0	0	59.78	1890	1918	1941	1947	1929	1933	1940	1946	1956	1944
0	1	4.78	1965	1924	1894	1920	1908	1880	1877	1847	1801	1804
0	1	9.77	1810	1829	1863	1831	1770	1728	1713	1695	1708	1702
0	1	14.76	1749	1774	1757	1775	1769	1781	1791	1812	1858	1837
0	1	19.75	1873	1831	1835	1804	1802	1803	1787	1784	1754	1729
0	1	24.74	1730	1747	1778	1821	1854	1890	1868	1855	1872	1898
0	1	29.73	1919	1947	1970	1958	1943	1917	1923	1928	1950	1920
0	1	34.72	1935	1946	1943	1919	1906	1882	1820	1789	1765	1758
0	1	39.71	1750	1728	1726	1729	1723	1717	1756	1815	1824	1825
0	1	44.70	1835	1810	1776	1752	1724	1723	1756	1757	1856	1890
0	1	49.69	1876	1989	2087	2053	2008	1993	1970	1939	1863	1850
0	1	54.69	1876	2034	2197	2249	2214	2155	2110	2056	2014	1967
0	1	59.68	1932	1892	1789	1616	1246	1027	919	885	913	1295
0	2	4.67	1621	1525	1324	1206	1225	1417	1824	2258	2397	2391
0	2	9.66	2644	1555	1425	1177	1044	1601	109	3770	3803	3538
0	2	14.65	2304	1978	3802	3802	3802	3802	3802	3802	3803	3714
0	2	19.64	1835	554	-183	-890	-1140	-1716	-1590	-1374	-675	-25
0	2	24.63	161	286	490	641	757	844	811	665	946	1192
0	2	29.62	1291	1311								

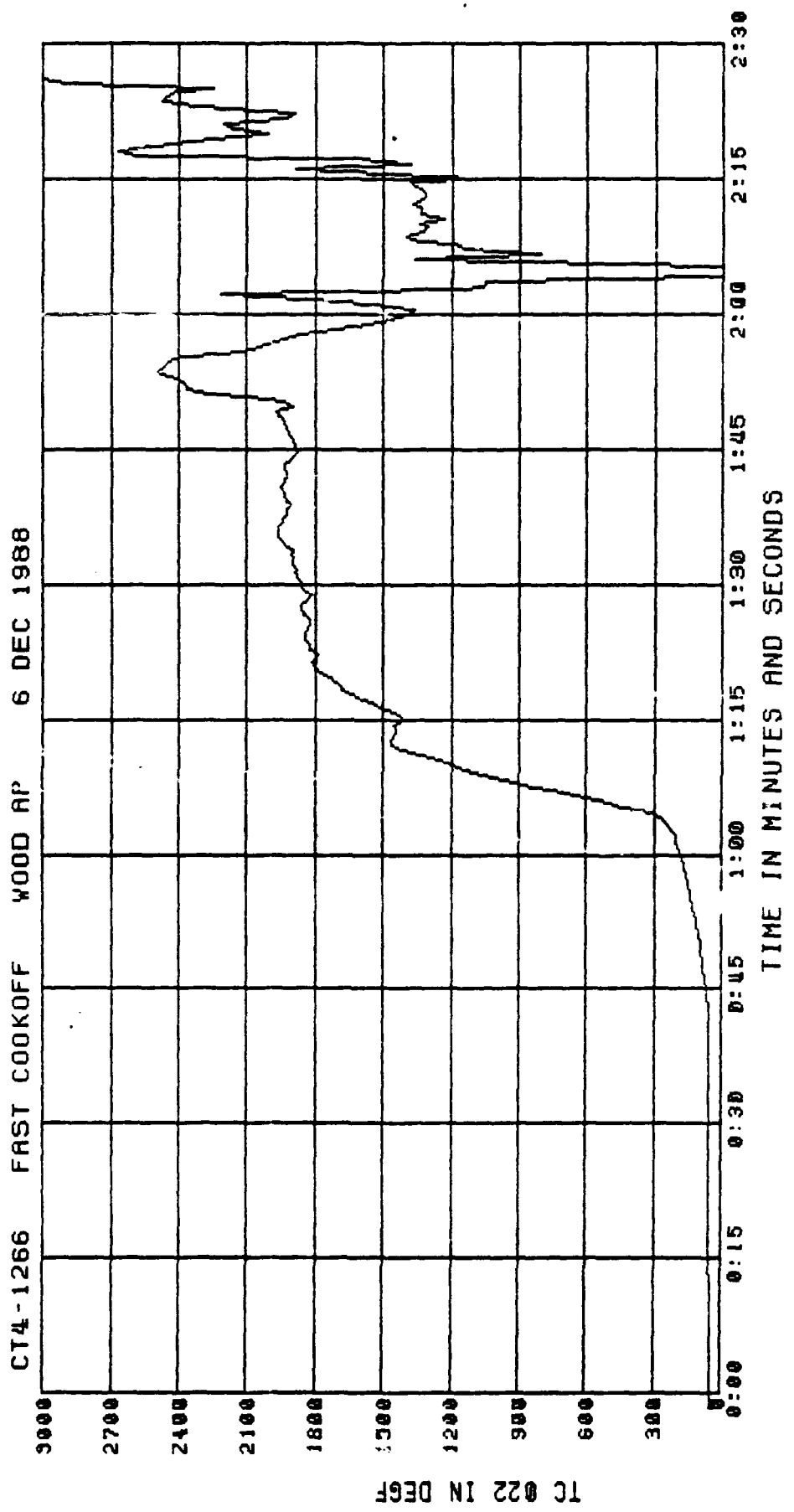
TIME IS FOR FIRST COLUMN OF TC 023. DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0.50 SECONDS

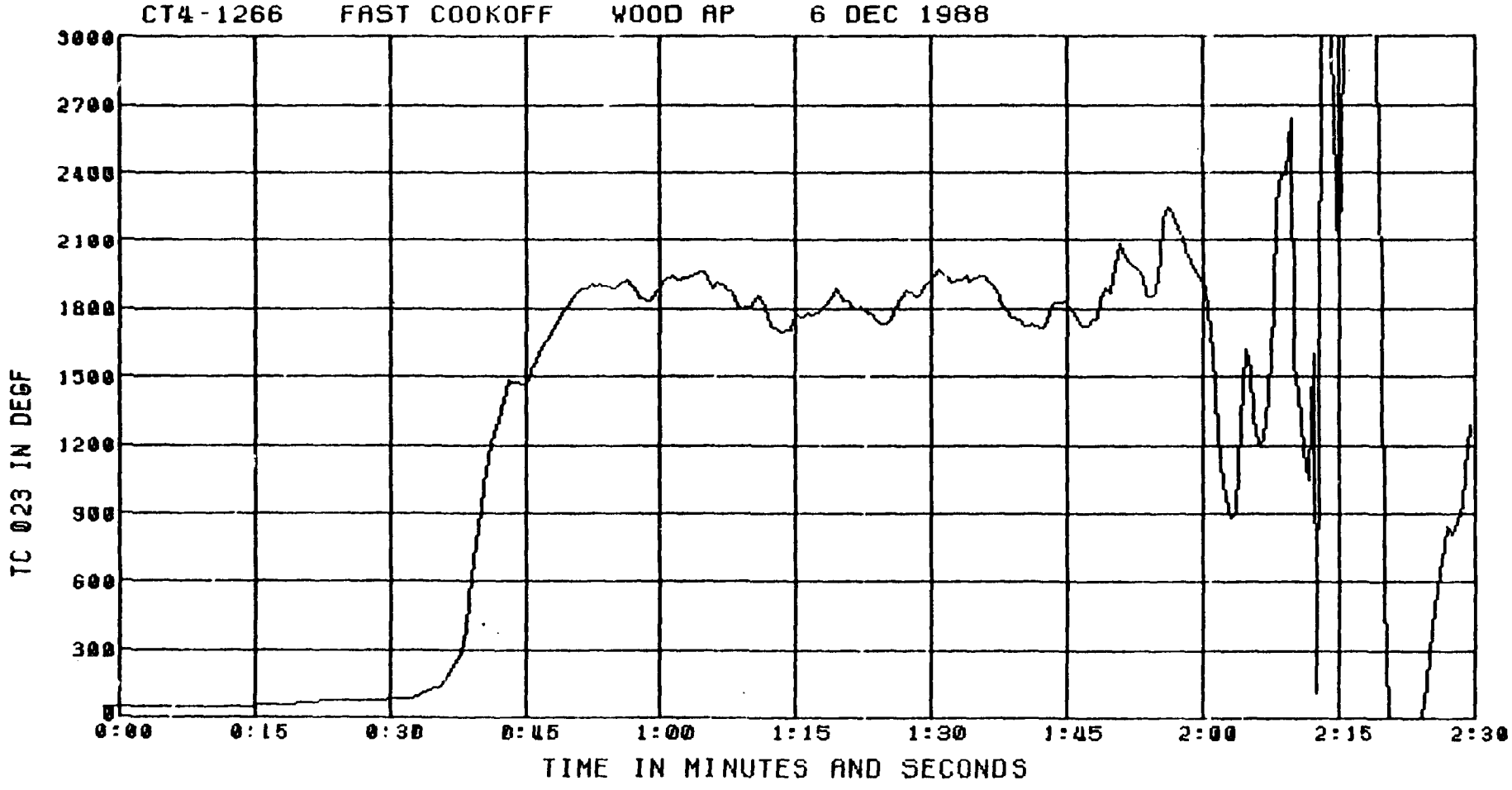
STS-1R88 FAST COOKOFF WOOD AP 6 DEC 1988

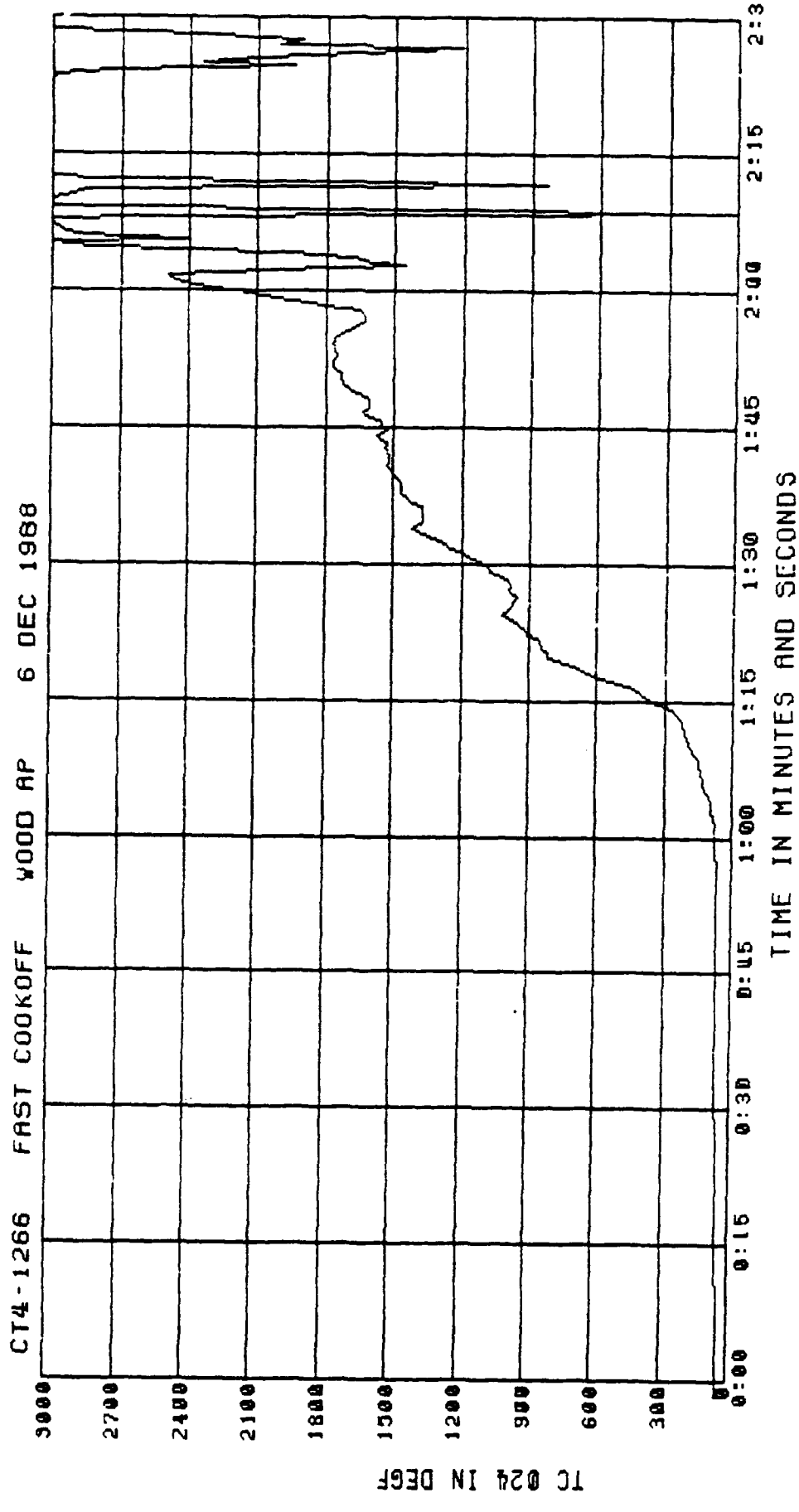
TIME HOUR	MIN	SEC	TC 024 DEGF	TC 024 DEGF	TC 024 DEGF	TC 024 DEGF	TC 024 DEGF	TC 024 DEGF	TC 024 DEGF	TC 024 DEGF	TC 024 DEGF	TC 024 DEGF
0	-1	0.00	46	46	46	46	46	46	46	46	46	46
0	0	-55.01	46	46	46	46	46	46	46	46	46	46
0	0	-50.02	46	46	46	46	46	46	46	46	46	46
0	0	-45.03	46	46	46	46	46	46	46	46	46	46
0	0	-40.04	46	46	46	46	46	46	46	46	46	46
0	0	-35.04	46	46	46	46	46	46	46	46	46	46
0	0	-30.05	46	46	46	46	46	46	46	46	46	46
0	0	-25.06	46	46	46	46	46	46	46	46	46	46
0	0	-20.07	46	46	46	46	46	46	46	46	46	46
0	0	-15.08	46	46	46	46	46	46	46	46	46	46
0	0	-10.09	46	46	46	46	46	46	46	46	46	46
0	0	-5.10	46	46	46	46	46	46	46	46	46	46
0	0	-0.11	46	46	46	46	46	46	46	46	47	47
0	0	4.88	47	47	48	48	48	49	49	50	50	51
0	0	9.87	51	52	52	53	54	54	55	55	56	55
0	0	14.87	56	57	57	57	57	57	58	58	58	58
0	0	19.86	58	58	58	58	58	58	58	58	58	59
0	0	24.85	59	59	59	59	59	60	61	61	61	62
0	0	29.84	62	62	62	63	63	63	63	63	64	64
0	0	34.83	64	63	63	63	63	63	63	63	63	63
0	0	39.82	63	64	63	63	63	63	63	64	64	64
0	0	44.81	64	64	64	64	64	64	64	64	65	65
0	0	49.80	65	65	65	65	66	66	66	66	65	67
0	0	54.79	67	68	69	69	70	70	71	72	72	72
0	0	59.78	73	74	75	79	82	86	90	93	98	105
0	1	4.78	114	122	127	133	138	144	148	150	158	177
0	1	9.77	187	197	210	213	216	221	227	243	265	301
0	1	14.76	334	382	406	440	500	551	616	665	693	779
0	1	19.75	813	818	841	856	862	905	916	946	985	1023
0	1	24.74	998	981	977	958	974	988	979	1002	1051	1079
0	1	29.73	1088	1119	1173	1201	1247	1268	1324	1374	1419	1401
0	1	34.72	1374	1368	1373	1373	1421	1438	1467	1468	1466	1471
0	1	39.71	1491	1514	1534	1524	1520	1529	1536	1533	1560	1574
0	1	44.70	1529	1554	1569	1610	1638	1617	1615	1625	1663	1700
0	1	49.69	1723	1730	1733	1747	1766	1768	1747	1758	1763	1774
0	1	54.69	1761	1736	1707	1655	1627	1630	1652	1727	1880	2019
0	1	59.68	2124	2301	2392	2463	2495	2035	1457	1598	1684	1985
0	2	4.67	2829	3298	2411	2898	2969	3568	3802	2586	-1418	3779
0	2	9.66	3776	3750	2912	2552	834	2797	3717	3795	3802	3802
0	2	14.65	3802	3802	3802	3802	3802	3802	3802	3802	3802	3802
0	2	19.64	3802	3802	3802	3802	3802	3802	3802	3715	2990	2729
0	2	24.63	1945	2340	2088	1659	1210	2006	1905	2305	3105	3241
0	2	29.62	3282	3636								

TIME IS FOR FIRST COLUMN OF TC 024 DELTA TIME BETWEEN TWO ADJACENT COLUMNS IS 0.50 SECONDS


CT4-1266 FAST COOKOFF WOOD AP 6 DEC 1988
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
TC 021 IN DEGF
0:00
0:15
0:30
0:45
1:00
1:15
1:30
1:45
2:00
2:15
2:30
TIME IN MINUTES AND SECONDS


CT4-1266 FAST COOKOFF WOOD AP 6 DEC 1988
TC 022 IN DEGF
3000
2700
2400
2100
1800
1500
1200
900
600
300
0:00
0:15
0:30
0:45
1:00
1:15
1:30
1:45
2:00
2:15
2:30
TIME IN MINUTES AND SECONDS


CT4-1266 FAST COOKOFF WOOD AP 6 DEC 1988
TC 023 IN DEGF
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
0:00
0:15
0:30
0:45
1:00
1:15
1:30
1:45
2:00
2:15
2:30
TIME IN MINUTES AND SECONDS


CT4-1266 FAST COOKOFF WOOD AP 6 DEC 1988
TC 024 IN DEGF
TIME IN MINUTES AND SECONDS
3000
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2400
2100
1800
1500
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900
600
300
0:00
0:15
0:30
0:45
1:00
1:15
1:30
1:45
2:00
2:15
2:30